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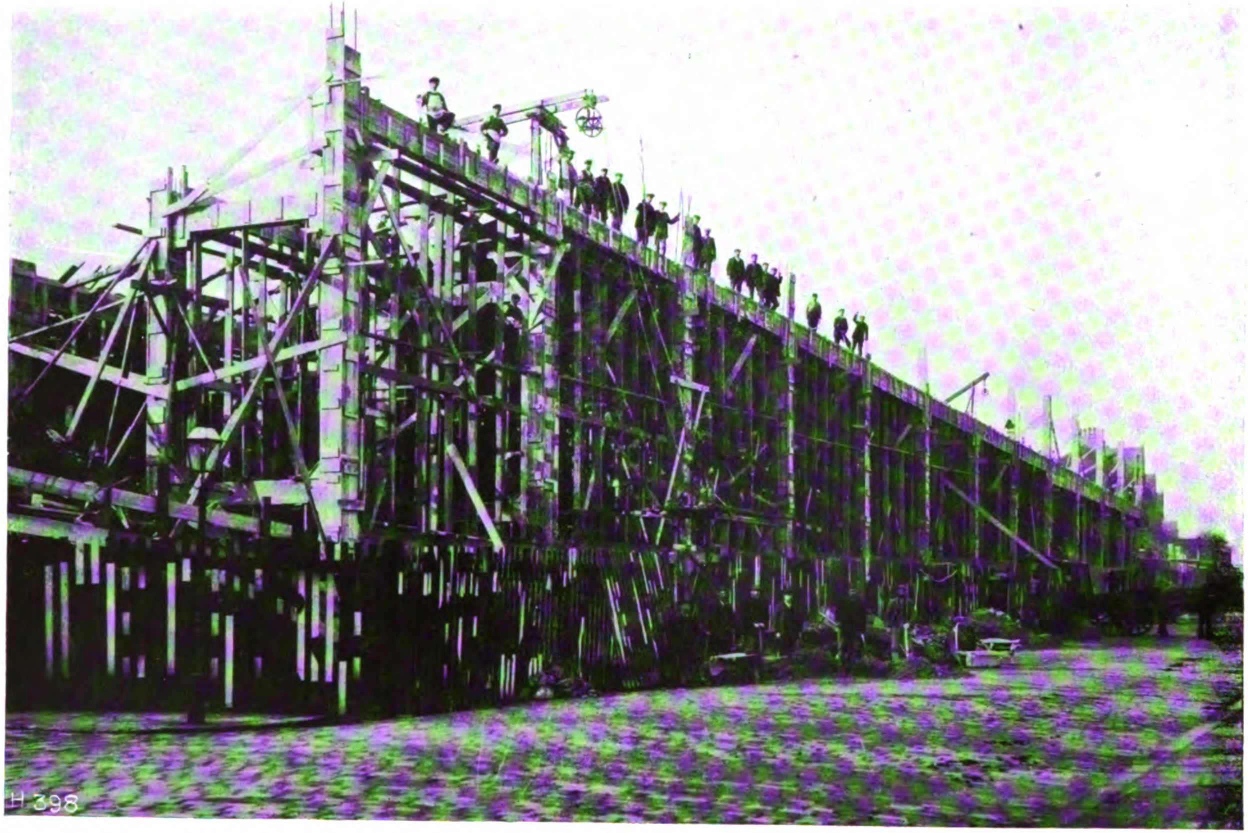

Reinforced Concrete Football Stand at Bradford
View in course of construction.

Frontispiece.
(Opp. Contents.)

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AND
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CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume V. No. 1. LONDON, JANUARY, 1910.

EDITORIAL NOTES.

OUR FIFTH YEAR.

WITH the present number this journal enters upon its fifth year, and thanks to the continued and increasing support we have received from our readers, and also owing to the ever-widening scope of the subject to which our paper is devoted, we are now entering into a sphere of even greater activity.

This will be the first year in which our journal will appear as a monthly all through the year, as the change from a bi-monthly was only effected during the latter part of 1909. Our development into a monthly has been received most favourably not only at home but also by our many readers in the Colonies and abroad.

REINFORCED CONCRETE IN THE YEAR 1909.

THE columns of this journal will have borne testimony to the development of reinforced concrete and its uses during the past year at home, in our Colonies, and abroad.

What has, perhaps, been a matter of primary importance to all those interested in the subject in the United Kingdom is the extent to which the material is now being employed for Government works, notably by H.M. Office of Works, the Admiralty, and War Office. The example set by the Government Departments in the application of reinforced concrete has been of the utmost value, for it has given that confidence which the material well merits, but which some of the ultra-conservative members of the technical professions have been slow to give it.

The only unpleasant feature in the Government's attitude during the past year has been the continued adverse attitude of the Local Government Board in refusing to grant loan periods of adequate length where local authorities desire to use reinforced concrete.

Of the many minor uses to which reinforced concrete has been applied, the progress made in its application for railway sleepers, telegraph poles, fence posts, pipes, etc., are, perhaps, the most notable instances.

It may be anticipated that with 1910 the development will continue still further. Interest in the material is increasing in every direction, and the fact that it is not only practical, but also very economical, is making itself felt among building employers, who are even demanding its use in many cases.

Legislation in connection with the use of reinforced concrete has also progressed in the right direction during the past year, and with 1910 we may expect further improvements which will facilitate the use of the material still more.

In one direction only we fear that its application has not progressed as we should have wished. We do not find that architects of high standing are devoting sufficient thought to the possibilities of reinforced concrete. If only some of the leaders in the architectural world were to strongly take up the matter, we believe the material would also find increased use amongst those who are rather prejudiced as to its appearance in buildings.

Speaking generally, however, the prospects for reinforced concrete are very bright, and building owners, members of the technical professions and the industries concerned, are likely to benefit materially by its greater application in the near future.

THE REPORT OF THE CONCRETE INSTITUTE ON STANDARD NOTATION.

WE have received from the Concrete Institute a copy of their report on Standard Algebraical Notation for Calculations.

Our first impression on seeing the number of terms for which a symbol has been provided was one of alarm lest our already overburdened memories be further taxed by a horrible super-tax of inexplicable notation. We recollect that in the first paper ever read before the Concrete Institute Mr. Charles F. Marsh, M.Inst.C.E., said :—

> "There are so many different symbols required that the available alphabets are hardly sufficient for the purpose, and when trying to deal with the calculations in a complete manner one sometimes wishes the Chinese alphabet were universally understood, as it might come in very useful when the Latin and Greek letters were all used up."

Upon examining the report before us, however, we notice that it is, on the whole, "just plain English," and that no call has been made on the alphabet of the Celestial Empire.

Cryptic and Egyptian hieroglyphics find no place in this report, and only a few of the best known Greek letters have escaped the censor's ban.

A careful and critical reading of the report shows that the adoption of the initial letter, the use of significant subscripts, the discrimination between the uses of the small and capital letters, and the sparing use of the Greek alphabet are the four cardinal principles which have enabled the committee to replace the capricious preferences of individual authors by the dictates of an impersonal logical necessity.

The report is not complete, the list is not perfect, but it will do very well to go on with. It is better than anything in the past, and it looks hopeful for the future.

It is the newness of reinforced concrete which makes such a report possible. In some of the older branches of engineering the dead weight of tradition would retard the acceptance of even that which was desirable, rational, and necessary for progress. Now that a start has been made we hope that the principles formulated in this report will be extended to other branches of engineering.

We learn on reliable authority that the principles laid down are winning wide acceptance, for they are simple, though the list may appear forbidding by its very length.

Yet, after all, this forbidding aspect is more apparent than real, and arises solely from the fact that we are so used to long lists of symbols, most of which offer no intelligible clue to the quantity symbolised.

It is noted that the essential principles of this report are applicable to any language, although the actual details would, of course, vary according to the words abbreviated.

As a matter of fact, we notice traces of the initial letter principle in German notation. For example :—

b = Breite = breadth.
b = Beton = concrete.
e = Eisen = iron.
h = Höhe = height.
D = Druck = compression.
Z = Zug = tension.
n = Nummer = number.
o = oben = top.
u = unten = bottom.

However, one swallow does not make a summer, and a few rational symbols do not constitute a system, be it German or French.

The great advance made by this report is that it absorbs all the natural abbreviations already existing in English notation, and consciously moulds all the rest on the same logical and intelligible basis.

Engineers may well envy the chemists their universal notation, but it must not be forgotten that chemists have a universal terminology, and have only about seventy elements, not thousands.

Engineers will have an international notation when they have an international language. Till then a universal system of symbols must remain a *vade mecum* for leisured and erudite linguists and for men with extraordinary memories.

THE PORTLAND CEMENT INDUSTRY IN 1909.

Now that we have arrived at the end of the year it is possible, although the precise figures are not yet known, to estimate with fair accuracy the extent of the imports of foreign cement into the United Kingdom during 1909, and it is gratifying to see that they show a very substantial falling off as compared with previous years. The imports from abroad reached their zenith in 1904, when 272,945 tons of foreign cement were cleared through our Custom Houses. Since then the fall has been rapid, and in 1908 the imports were only 93,684 tons. For the year just closed they will not much exceed 65,000 tons. Of this quantity all but about 4,000 tons has come from Belgium, and of the latter practically the whole consists of the so-called "Natural" cement, the character of which has been so frequently described in these pages.

In considering the causes which have contributed to this result, the steady fall in the price of first-class artificial Portland cements, which has been such a striking feature of the past two years, has undoubtedly had some effect. When the builder is able to obtain a high-class constructive material at little more than the price of the inferior Belgian cement he has less temptation to risk the loss which arises from failure of the work. After all, the quantity of Portland cement required in the construction of the average house is not great, and the *maximum* saving which can be effected by the use of the Belgian material, even assuming that the builder uses no larger proportion of it when mixing his concrete than he would use if a genuine artificial Portland cement were employed, is very small. But an even greater contributory cause will undoubtedly be found in the wider knowledge and experience which each additional year has brought to those who were first tempted by the comparative cheapness of the "Natural" cement. A single bad failure may easily cause more loss than the apparent economy secured by the use of this material on a very large number of jobs, and when a man has suffered in this way he begins to find that cheapness is not always synonymous with a low price. Then, again, the information concerning the true character of Belgian "Natural" cements which has from time to time appeared in these pages has undoubtedly done a good deal to discourage the use of a material of so uncertain and unreliable a character. Finally, we think that a good deal is due to the wider adoption of the British Standard Specification for Portland cement, and a more careful insistence upon the compliance therewith. A larger proportion of engineers and architects now insist upon the frequent testing of the cements used upon their work, and even when they do not test the cement themselves, and do not employ one of the professional experts to do the work for them, they insist on seeing the results of the manufacturer's own tests of the particular parcel from which the cement used on their work has been supplied. When this has been done the professional man, who knows the reputation of the different makers, and who insists upon the cement being supplied only in packages bearing the name of the actual manufacturer, receives an assurance of prime importance. The Belgian "Natural" cement, however, cannot comply with the requirements of the British Standard Specification either in specific gravity or in the soundness tests, and its more frequent examination has revealed its inferiority so frequently as to effectually discourage its use.

But whilst imports of cement have thus fallen off so substantially, it is gratifying to find that the exports of British cements have been well maintained during the present year. There is a falling off, but this is very slight, and we estimate the total exports for 1909 at 590,000 tons, or about 8,000 tons less than during 1908. The decrease is mainly in the exports to Egypt and to Canada. The former is accounted for by the financial crash which took place in that country some time ago, and which necessitated the strictest retrenchment in Government expenditure. In Canada, however, the decrease is due to the steady development of cement manufacture in the Dominion. As a set-off, the exports have increased to Mexico and the various South American countries.

REINFORCED CONCRETE TELEGRAPH POLES.

It may have been observed that in recent issues we have been able to give a considerable amount of space to matters relating to reinforced concrete telegraph poles. We desire to point out particularly to our Colonial authorities the advantages of reinforced concrete telegraph poles compared with those of timber or metal.

Originally, almost the monopoly of one inventor, we have lately referred in our columns to no less than four methods of making reinforced telegraph posts. Two hail from Germany, one from Denmark, and one from Switzerland, and we are glad to observe that if Great Britain has not been a pioneer in the matter of invention, at least one of these four methods has now been introduced into this country under favourable auspices, and the first of the reinforced concrete pole factories in England has just been started in Essex.

There is no surer test of the utility of a product than its advent from different directions and in different forms.

There is no doubt that the application of reinforced concrete to poles used for telegraph, telephone, and similar transmission purposes is a step in the right direction, and that there is a wide field for the makers of poles and posts which combine efficiency with economy.

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SKELETON CONSTRUCTION AND THE AMENDED LONDON BUILDING ACT.

The L.C.C. General Powers Act.

The article here presented summarises some of the leading features of the new Amendments to the London Building Acts, for the excellent conception of which the Metropolis is in the main indebted to the London County Council's Superintending Architect, Mr. W. E. Riley, F.R.I.B.A.—ED.

AN article published in our issue of March, 1906, sets forth clearly some of the inconveniences and hardships endured for many years by architects, builders, and others owing to the unnecessary restrictions against the rational employment of steel, which were perpetuated by those responsible for the London Building Act of 1894.

Since the date of that article a Bill has been brought before Parliament by the London County Council conferring various powers upon that body, and containing in Part IV. authority to amend the London Building Acts so as to bring those statutes into line with modern constructive practice.

The amendments in question have now been fully considered, and, with some modifications, approved by committees of the House of Commons and the House of Lords. Consequently, they obtained the Royal Assent, and the much desired reforms have come into practical effect.

In the present article we need not refer to the history of the movement whose aims have been realised, nor to the various points which became subjects for controversy when the amendments were under consideration by the two Parliamentary committees. The amendments as originally drafted, under the advice of Mr. W. E. Riley, F.R.I.B.A., were energetically opposed by the Royal Institute of British Architects, the Institution of Civil Engineers, the Surveyors' Institute, and other bodies, but were very effectively supported by the British Fire Prevention Committee, whilst the battle waged round the subject was one of unusual technical interest.

Our object, however, is not to deal with the bygones, but to give facts of an essentially practical character, and in what follows we devote attention simply to the nature and application of the main sections relating to the construction of metal frame buildings. In order that our readers may see at a glance the purport of the amendments embodied, we give in the subjoined table a synopsis of the sections added to the London Building Act, 1894, as also a list of the sub-sections of the all-important Section (22). The amendments comprise Section (20), defining the "principal Acts," Section (21), interpreting this part of the Act, and Section (22), comprising the provisions as to metal skeleton construction. Section (22) has 35 sub-sections, as indicated below :—

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WALLS:	
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PILLARS—STEEL AND WROUGHT IRON:	
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PILLARS—GENERAL:	
Bedding of base	14
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At the outset it should be pointed out that the amendments contained in Part IV. of the "London County Council (General Powers) Act, 1909," do not limit the metal employed in skeleton buildings to iron or steel. The latitude denoted was not at first prominently set forth, but is made clear in the final form of the Bill.

For instance, Section (22) makes it lawful to erect "buildings wherein the loads and stresses are transmitted through each storey to the foundations by a skeleton framework of metal," no particular description of metal being specified.

Again, Section (21) states that every pillar and girder of the kind contemplated by the Bill shall mean a metal pillar and girder.

As the wording now stands, any structural metal standardised by the Engineering Standards Committee after the passing of the Act may only be used subject to such conditions as may be established by the County Council, the latter proviso apparently being intended to govern the application of structural metals which at present have not been discovered, or, at any rate, which have not been standardised by the Engineering Standards Committee.

The second paragraph of Section (21) permits a metal pillar to be built up of stanchions properly riveted or bolted together. This is not quite satisfactory, for an assemblage of T-bars, I-bars, or channels bolted together would not represent good work. However, as sub-section (10) of section (22) states that "rivets shall be used in all cases where reasonably practicable," and sub-section (31) provides for the approval of detailed drawings and calculations by the district surveyor, it may be taken that sufficient powers are given for the frustration of attempts in the direction of unjustifiable economy.

PROVISIONS WITH RESPECT TO SKELETON CONSTRUCTION.

A point of considerable importance is embodied in the opening paragraph of Section (22), where it is made clear that the provisions in the succeeding sub-sections shall apply not merely to the exterior skeleton framework of a building, but also to "the foundations, walls, floors, staircases, and other parts of the structure." Such of these details as are of metal actually form integral portions of the metal framework, and it is quite proper that they should be so dealt with. If the idea of some opponents to the section had been accepted by Parliament the future of steel skeleton construction would have been seriously prejudiced. To provide for the strength of a skeleton consisting merely of outer columns and beams it would be necessary to employ more metal than that required in a skeleton comprising interior members acting as effective bracing. Thus the tendency of the section as finally settled is towards economy, while at the same time affording a guarantee of sound design throughout the metal structure.

STEEL TO COMPLY WITH BRITISH STANDARD SPECIFICATION.

Sub-section (1) provides that all rolled steel used in skeleton construction shall be in accordance with the "British Standard Specification for Structural Steel." This stipulation will have the effect of debarring the employment of cheap foreign steel of low tensile strength, such as is frequently substituted for British steel by persons who pay more attention to the price per ton than the physical properties of material. The objection has been raised that disputes will probably occur relative to the precise methods of making tests and as to the fairness of the methods adopted by testing specialists. We really do not think the least trouble of the kind need be anticipated. All the leading steel makers and rolling mills now turn out rolled sections complying with the British Standard Specification, and are quite accustomed to submit their products to independent testing experts. Moreover, civil engineers always specify that steel used on important works shall be tested before acceptance, a condition which causes no difficulty in practice. Another fear expressed is to the effect that the legal establishment of the British Standard will lead to the employment of harder and more brittle steel with the minimum of ductility. This is a purely hypothetical objection, which would not occur to anyone who has made himself familiar with the safeguards provided in the Standard Specification.

An omission of some importance is the absence of any specified standard quality for wrought iron, cast iron, and cast steel. Wrought iron is no longer used for the main elements of pillars and girders, but is still employed to a limited extent in the form of small bars, bolts, and rivets. Hence the Bill ought to specify the standard with which the metal should comply. Cast iron is employed in the form of pillars and other structural details, and cast steel may enter into skeleton framework. These varieties of metal ought also to be in accordance with some recognised standard. The absence of any safeguard with respect to the properties of the metals mentioned is somewhat unfortunate.

FIRE PROTECTION.

Sub-sections (3), (4), and (5) relate to the fire protection of metal pillars and girders throughout every skeleton building. All external pillars must be completely encased by incombustible material to the thickness of at least four inches, the whole being properly bonded together ; all external girders must be similarly protected to the same thickness except at the underside and the edges of the flanges, where the protective casing need not be more than two inches thick ; all interior pillars and girders must be likewise protected to the thickness of not less than two inches. The only exception we take to these provisions is the implied recognition in sub-section (5) of " plaster " and of dense terra-cotta as efficient fire-resisting materials for covering interior pillars and girders. In all other respects the three sub-sections represent a welcome reform which might advantageously be extended to all iron and steel members employed in ordinary building construction.

SPECIFIC PROVISIONS.

Girders.—The concessions to economy represented by the permission in sub-section (8) to fix together by " iron separators and bolts " two or more adjacent girders or joists intended to act together is one which should be applied with discrimination. The House of Commons Committee properly stipulated that the connection of joists in this way should only apply to members closely adjacent to one another, but the sub-section is still rather unsatisfactory because it insists upon the use of iron for separators, thereby debarring steel in any form, and because it does not define the meaning of the term " separator." A piece of gas-pipe would answer the purpose after a fashion, and there is nothing to prevent its use, except perhaps an objection on the part of the district surveyor.

Joints.—Sub-section (10), prescribing the use of rivets in all cases where reasonably practicable, may probably be applied to limit the employment of iron separators and bolts. Some opposition was threatened to this sub-section, on the ground that field-riveting would introduce a new trade into building operations, and so cause much extra trouble and expense. Fortunately, as we think, the original wording was approved by Parliament, and so an assurance is given that bolted joints shall only be adopted in exceptional cases, instead of becoming the general rule.

Walls.—The first four lines of sub-section (11A) embody the great reform long awaited by the advocates of skeleton building construction in this country.

They provide that the enclosing walls, or portions of external walls carried by metal framework need not be thicker than 8½ in. for the topmost 20 ft., or than 13 in. for the remainder of the height. No permission is given to carry buildings to a greater elevation than that contemplated by previous enactments, so that the building of "sky-scrapers" is not legalised. But henceforward those adopting the metal framed system of construction will be freed from the vexatious restrictions established many years ago and confirmed by the London Building Act of 1894.

To the privilege thus conferred is added the option of employing a less thickness than 8½ in. in any case where such less thickness is prescribed under the Act of 1894. Sub-section (11B) demands that all party walls "shall be of the thicknesses prescribed by the principal Acts."

In the case of a detached building there would obviously be no party wall, and in consequence the metal framework in the front and back walls would be efficiently connected and braced by the framework in the two end walls, as well as by the interior framework represented by floor girders.

If, however, two or more contiguous buildings are erected all to the same general design, and divided up by partition walls for the convenience of separate owners or tenants, the dividing or party walls must be of the thicknesses prescribed by the principal Acts, and need not include any metal framework, the absence of which will naturally tend to impair the completeness and continuity of the metal skeleton. In cases of the kind here contemplated architects will have to choose between two alternatives: (1) To design the skeleton framework for supporting only the front and back external walls, and sometimes for supporting also the two external walls at the extremities of the block; and (2) to design a complete skeleton for all four walls of each portion of the general building, thereby making twin curtain walls carried by the metal skeleton instead of building thick party walls of masonry.

The first alternative suggests the possible development of an undesirable form of construction embodying detached lengths of front and back framework built into thick party walls and not braced in a particularly efficient manner.

The second alternative is conducive to the design of more rigid framework, but the additional cost involved will probably militate against its adoption.

If it were not for the impossibility of providing for dual ownership in one side of a metal skeleton the provision demanding thick masonry party walls would be unnecessary. The best mode of procedure is for every building to be designed with its own complete framework, which will then never be required to carry outer walls of more than 13 in. thick.

A satisfactory feature of sub-section (11C) is the demand that all Portland cement used shall be in accordance with the British Standard Specification, this stipulation being one that will obviously check the use of fictitious "Portland" cement now imported in large quantities from abroad. In party walls of the type demanded by the principal Acts lime mortar may be employed as heretofore, except in parts immediately surrounding metal framework.

Fire-resisting Construction.—Sub-section (16) embodies a stipulation concerning the employment of fire-resisting materials, which is a useful addition to the requirements stated in sub-sections (3) to (5). While duly grateful for these movements in the direction of fire-resisting construction, we hope that before many years have passed the application of the same principles will be made compulsory throughout all details of skeleton and ordinary buildings in the central districts of London.

Loads.—After defining what is meant by dead and superimposed loads, sub-section (18) gives in paragraph (*c*) a statement of the estimated dead load equivalents of the superimposed loads on the floors and roofs of various classes of buildings. The equivalents here stated are intended for the purpose of calculating the loads on pillars, piers, walls, framework, girders, and other constructions carrying loads in buildings. As the paragraph is worded it would apply to all buildings were not its scope limited to metal skeleton buildings by the opening paragraph of Section (22).

The provisions of the sub-section are summarised for ready comparison in the subjoined table :—

TABLE OF DEAD LOADS EQUIVALENT TO THE SUPERIMPOSED LOADS ON EACH FLOOR AND ON THE ROOF OF METAL SKELETON BUILDINGS.

Class of Building and Intended Use	Part of Structure Loaded	Load [1] per sq. ft.
Domestic Building (intended to be used wholly or principally for the purposes of human habitation or for domestic purposes)	Floor	70 lb.
Office Building (intended to be used wholly or principally for the purpose of an office or a counting house, or for any similar purpose) ...	Floor	100 lb.
Workshop or Retail Shop Building	Floor	112 lb.
Warehouse Building (not intended to be used wholly or principally for any of the purposes aforesaid)	Floor	224 lb.
Every Class of Building (roof inclined at more than 20° with horizontal)	Roof	28 lb. [2]
(roof inclined at less than 20° with horizontal) ...	Roof	56 lb. [3]

[1] If the superimposed load is to exceed that specified in this column, such greater load shall be provided for pursuant to sub-section (2), and if the floor is to be used for a purpose for which a superimposed load is not specified in this sub-section the superimposed load shall be provided for pursuant to sub-section (2) of Section (22).

[2] Per square foot of sloping surface.

[3] Measured on a horizontal plane.

The floor load equivalents covered by the sub-section will doubtless be found convenient for approximate calculations relating to average practice. Of course, the loads will often be considerably greater than those stated, and to provide for such cases and other intended purposes an additional paragraph was inserted in sub-section (18) to the effect summarised in footnote (1) to the foregoing table.

Comparison of the wording in footnotes (2) and (3), which are copied verbatim from the sub-section, reveals an apparent lack of clearness as to the precise meaning intended by the expression "per square foot of sloping surface." If we interpret the meaning correctly the first paragraph denoted would be improved by omitting the words we have printed in square brackets and by inserting the words we print in italics, thus :—

" For a roof the plane of which inclines upwards at a greater angle than 20° with the horizontal the superimposed load (which for this purpose shall be deemed to include wind pressure) shall be estimated at 28 lb. per sq. ft. [of sloping surface] *measured on the inclined plane of the roof.*"

As so modified the wording would be free from ambiguity, and harmonise with that of the next paragraph, which reads :—

" For all other roofs the superimposed load shall be estimated at 56 lb. per sq. ft. measured on a horizontal plane."

Apart from the foregoing point the new regulations defining the superimposed roof loads to be taken into account by designers are not quite satisfactory.

To begin with, we have two arbitrary classes divided by an imaginary line, and including : (1) Roofs inclined at any angle between 20° and 90° with the horizontal ; and (2) roofs inclined at any angle from 20° down to 0° with the horizontal.

Notwithstanding the considerable range of inclination prescribed the superimposed loads are to be taken at the uniform unit values of 28 lb. and 56 lb. for the two classes respectively.

In the case of Class I. the only superimposed loads contemplated are evidently wind pressure and the weight of snow. Taking as a basis the horizontal wind pressure of 40 lb. per sq. ft., the customary equations give for various inclinations from 20° to 60° with the horizontal the normal pressures per sq. ft. stated below.

Inclination of Roof	Normal Wind Pressure
20	18·4 lb.
25	22·6 ,,
30	26·5 ,,
35	30·1 ,,
40	33·3 ,,
45	36·0 ,,
50	38·1 ,,
55	39·4 ,,
60	40·0 ,,

Allowing 5 lb. per sq. ft. for the possible snow load on a slope of 20°, and assuming the snow load to be progressively reduced to zero at the slope of 60°, we find that for roofs of $\frac{1}{5}$ and $\frac{1}{4}$ pitch the prescribed load of 28 lb. per sq. ft. would not be far wrong, while for greater inclinations it is obviously quite inadequate.

In the case of Class II. the snow load increases and the wind pressure decreases with the reduction of slope, but taking the snow load at the uniform value of 5 lb. per sq. ft., and assuming the horizontal wind pressure of 40 lb. per sq. ft., we have the following values :—

Inclination of Roof	Normal Wind Pressure	Snow Load	Total Superimposed Load per sq. ft.
20 deg.	18·4 lb.	5 lb.	23·4 lb.
15 ,,	14·2 ,,	5 ,,	19·2 ,,
10 ,,	9·6 ,,	5 ,,	14·6 ,,
5 ,,	5·1 ,,	5 ,,	10·1 ,,
0 ,,	0·0 ,,	5 ,,	5·0 ,,

Of course, some provision must be made for loads other than wind pressure and the weight of snow upon flat roofs and roofs of low pitch. The minimum of 56 lb. per sq. ft. is reasonable for a flat roof, and equally unreasonable for one with the inclination of 20°, the latter point being demonstrated by the fact that, according to the new Act, the minimum load on a roof with the slope of 20° 1′ is only 28 lb. In other words, the load suddenly jumps up a quarter of a hundredweight as soon as the imaginary line of demarcation between the two classes has been passed.

Rational methods of computing roof loads are perfectly simple, and it is to be regretted that the new Bill should legalise incorrect rule-of-thumb methods of computation.

Except so far as influenced by the preceding sub-section, the provisions of sub-sections (19) and (20) are judicious additions to the London Building Acts.

Working Stresses.—Sub-section (21) as originally drafted defined the permissible working stresses for cast iron, mild steel, and wrought iron pillars on the basis of the alternative ratios—*length to least width*, and *length to least radius of gyration*. The first of these ratios is now obsolete, and affords no reliable index to the effective proportions of a pillar. The second ratio can be calculated without trouble, the process being facilitated by the fact that the radii of gyration for every British Standard section are given in the handbook published by the Engineering Standards Committee. A few experimental calculations will show that the safe loads for pillars computed by both of the alternative methods may differ by fully 20 per cent. In a large building with pillars under heavy loads the discrepancy might easily run to 200 tons per column, representing a total discrepancy amounting to thousands of tons. Thus the authorisation of an admittedly inaccurate method might have involved much waste of metal and consequent increase of cost without any advantage. For these reasons we are very glad to find that in its final form the Bill makes the ratio of *length to least radius of gyration* compulsory for determining the stresses in all metal pillars. This is an amendment upon which the professional advisers to the County Council are to be congratulated.

Two new paragraphs (C) and (D) in sub-section (21) make suitable provision for eccentric loads on pillars, thereby making good a serious omission characterising the previous form of the Bill.

Drawings and Calculations.—Sub-section (31) makes demands which were the cause of some opposition on the part of engineers, but we think the Parliamentary Committee were right in upholding the requirement that notices served on the district surveyor under Section (145) of the London Building Act, 1894, should be accompanied by detailed drawings and calculations of loads and stresses. It is certain that no skeleton building can be designed without the preparation of such drawings and calculations. Consequently, the obligation to furnish copies cannot possibly cause any inconvenience or appreciable expense.

Qualified civil engineers may reasonably object to submit their drawings and calculations for approval to district surveyors, who, if merely architects, are not in a position to pronounce judgment personally, and so will be compelled to take the advice of engineering assistants. We quite sympathise with the view that an eminent civil engineer would be placed in an undignified position if called upon to submit to the dictation of an unknown assistant engineer in the employ of a district surveyor. Still, we are compelled to recognise the point that the safeguards embodied in this sub-section are not directed against eminent engineers and architects with adequate engineering training, but are intended to obviate possible errors on the part of designers who may adopt skeleton construction without previous experience in that special branch of work. The position would be more satisfactory if all district surveyors were doubly qualified as engineers and architects, an ideal which will probably be realised in the long run.

Finally, although the regulations embodied in Part IV. of the new Act are not entirely free from points capable of further improvement, it must be admitted that their general purport is good, and that a great obstacle in the way of scientific building construction has been definitely removed.

We cannot conclude this article without expressing our great satisfaction in noting that the County Council have taken the wise course of rectifying sundry important defects in the text as approved by the House of Commons Committee. This is an additional proof of the earnest desire evidenced by Mr. W. E. Riley to make the new regulations as perfect as possible, and for which he deserves the gratitude of engineers, architects, contractors, and the public generally.

WE have received the following communication on the subject of the new amendments for steel frame structures from Mr. S. Bylander, the well-known steel designer associated with Messrs. Waring & White, Ltd., and we are adding this as an appendix to the foregoing article on "Skeleton Construction and the Amended London Building Act."

APPENDIX.

A GREAT advance in the adoption of steel frame for buildings in London may be expected, since the new Act permits 14-in. thick walls for the entire height of a building supported on steelwork. (In fact, a 9-in. wall is allowed for the topmost 20 ft.)

The advantage as to economy is, however, not so great as might have been expected, as the minimum thickness of walls facing streets is practically limited to 18 in. on account of requirements of the architectural design.

Where only plain brick walls are required, such as for area walls in the centre of a building, the advantage is more clearly marked, both as to economy and simplicity in construction. For instance, in a building having five storeys above the first floor, the walls, according to the old Act, had to be 2 ft. 3 in. between the first and second floors, although supported on heavy girders at every floor level. The new Act permits 14-in. walls for a similar building, much lighter girders being required.

What is of far greater importance, however, is the fact that the new Act will encourage better construction on lines of good engineering, and thus provide stronger buildings for less, or at least the same, cost.

Architects and engineers will have definite data to work from, and must design the steelwork carefully and with due regard to safe loads and stresses, and while permitting more freedom in design, a more rational and economical form of construction can be adopted. The Act specifies the maximum stresses which may be used, while,

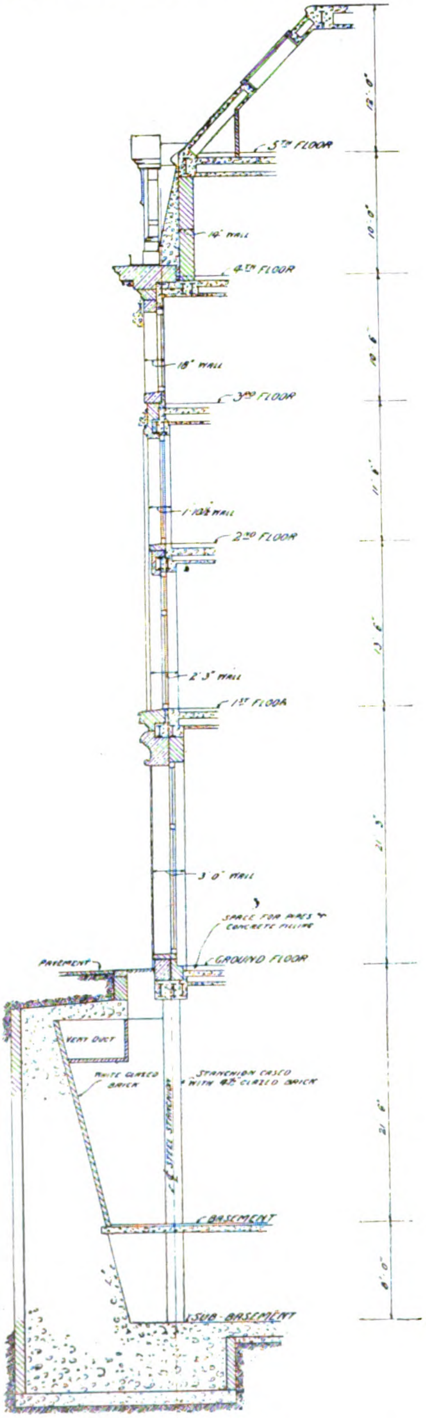


Fig. 1. Section as required by Old Building Act.

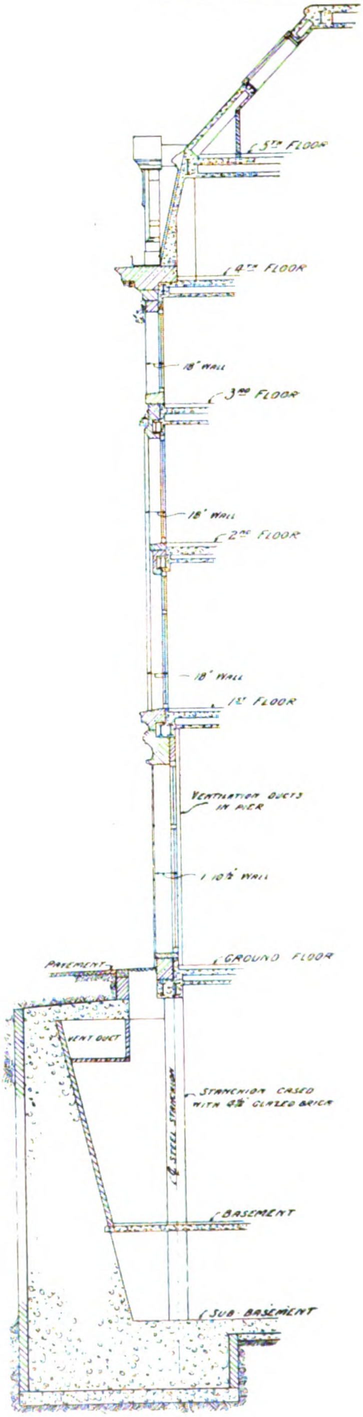


Fig. 2. Section as required by New Building Act.

SECTION OF "MORNING POST" BUILDING, LONDON.

of course, the owner will require as high stresses as may be permitted for the purpose of keeping the cost down. Extremes are therefore prevented from both sides.

A comparison of the construction required in conformity with the old and the new Act can be seen in *Figs.* 1 and 2 respectively.

Fig. 1 is a section of the front exterior wall of the *Morning Post* building in the Strand, London, as built in accordance with the old Act, and *Fig.* 2 shows how the walls could now be built according to the new Act of 1909.

The need of revision of the old Act is very evident from the fact that a building surrounded by streets on all sides and having no interior party walls could most probably be built without any exterior walls up to first floor, and the thick walls supported on cast-iron columns of very small diameter (to suit shop windows) and extending down to basement floor; thus no reliable lateral rigidity would be assured.

The new Act requires the structure to be rigid to withstand lateral pressure.

Referring to *Fig.* 1, it will be seen that the thickness of piers at ground floor is 3 ft. This is done entirely for the purpose of obtaining deep reveals for ground floor windows.

At the ground, first, second, third and fourth floors the thickness of walls is 3 ft., 2 ft. 3 in., 1 ft. 10½ in., 1 ft. 6 in., 1 ft. 1½ in. respectively. They could now be built much thinner in conformity with the new Act, as shown in *Fig.* 2.

As the old Act specifies that the roof for a building of the warehouse class must not make an angle with the horizontal of more than 47 degs. a mansard roof could therefore not be built without adopting the method shown for roof between fourth and fifth floors, namely, by building a wall of regulated thickness and filling up with concrete to form the mansard roof. The roof is thus considered to start at the fifth floor.

This construction is, of course, irrational, but the London County Council would now appear to have power to modify the requirements in similar cases, as shown in *Fig.* 2.

It may be added that the *Morning Post* is an office building, and not a warehouse, save the basement, where the printing machines are placed.

It is hoped that the London County Council will soon issue regulations for the use of reinforced concrete similar to those now contained in the new Act for structural steel.

REINFORCED CONCRETE FOOTBALL STAND AT BRADFORD.

The structure that we are describing is one of considerable technical interest, and is an excellent example of the practical and economical application of reinforced concrete for the many structures necessary in connection with our various sports—notably, race stands, football and cricket stands.—ED.

A NOTABLE example of reinforced concrete construction is to be seen in the large football stand of which we show illustrations, and which was recently erected for the Bradford City Football Club, Ltd., at Midland Road, Bradford.

The whole of the new stand has been constructed in reinforced concrete, with the exception of the covering roof.

In plan the stand has a length of 330 ft. and a breadth of 27 ft. 4 in. at its wider end, diminishing uniformly to 13 ft. 4 in. at the narrower end.

The stand platform is partly inclined and partly horizontal, the horizontal portion forming a distributing passage and the inclined portion being stepped with concrete degrees to enable the crowd to see the field of play.

The area of the inclined flooring and passage supported is 6,948 sq. ft., and the upper level of the flooring is 34 ft. above street level.

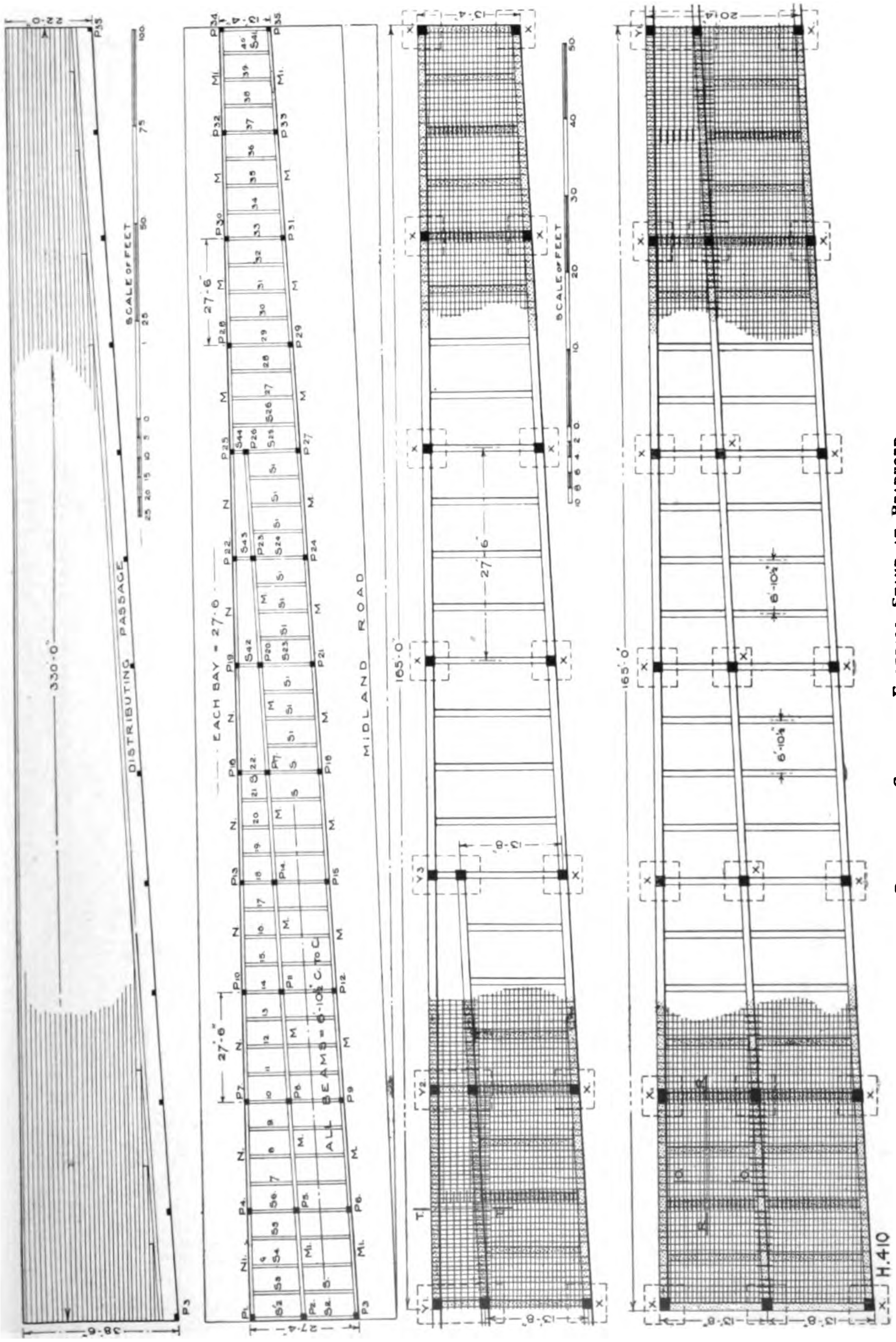
The columns are of varying sections and rise to a total height of 40 ft. above street level for the support of the iron principals of the roof. The reinforced concrete decking slab has an effective depth of 4 in., and is reinforced by a grillage of bars over its entire area. The secondary beams run transversely, and they are therefore all inclined to the horizontal.

In order to provide for the change of plane in the flooring, *i.e.,* from inclined to horizontal, the secondary beams were formed of special design to admit of this in the back row, and consequently the depth varies in the length of the beam, as can be seen from our illustrations. We have called special attention to this point, as it affords a demonstration of the exceptional adaptability of reinforced concrete construction.

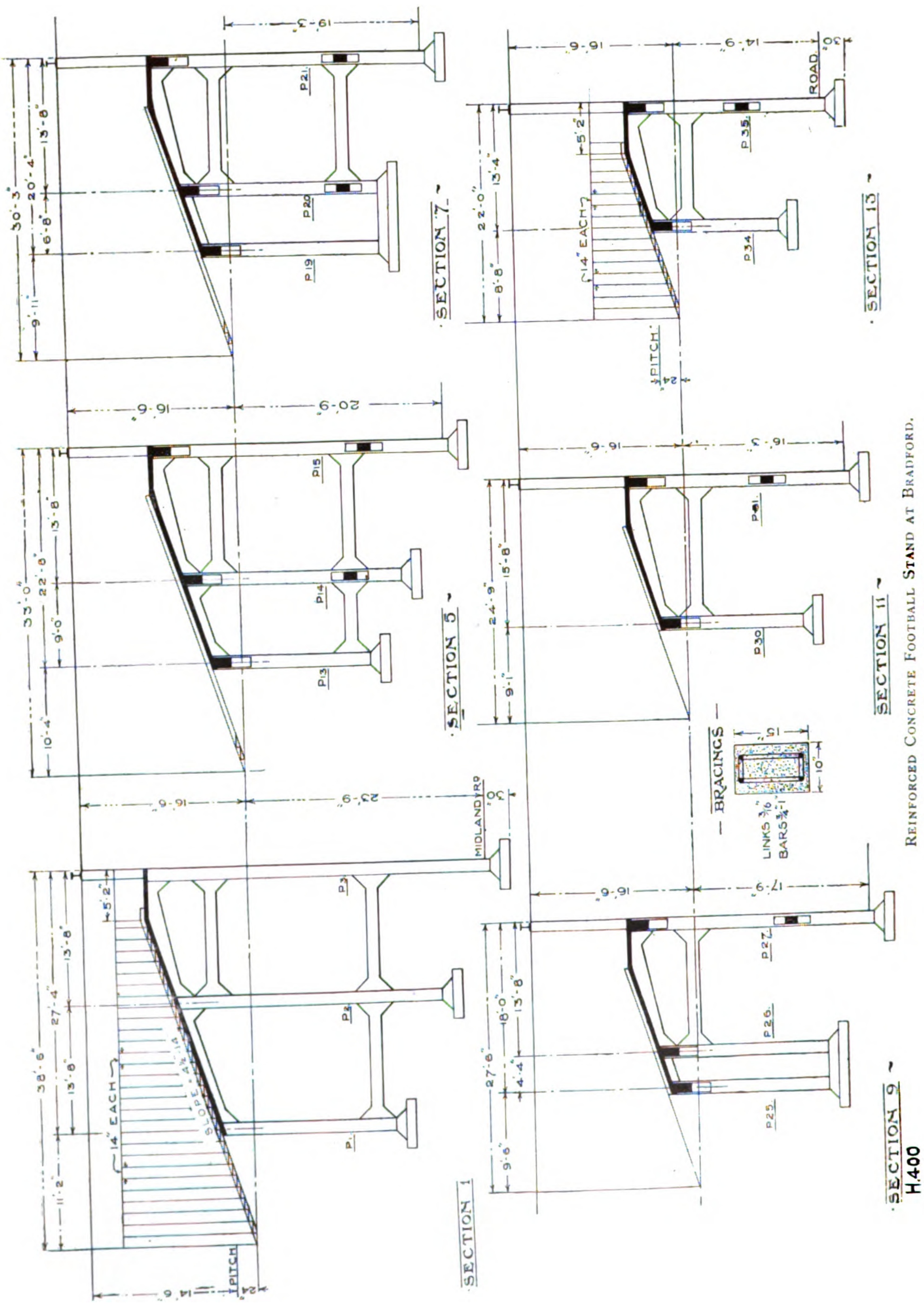
The main beams and lintels run longitudinally, and have a section 12 in. in breadth by 21 in. depth, measured on the vertical axis of the beam. These beams have a clear span of 26 ft. 3 in., and the columns are at 27 ft. 6 in. centres.

The concrete degrees were formed by being laid solid on the reinforced concrete decking after the latter had set. These degrees are bonded to the reinforced concrete decking slab by means of frequent wire ties, so as to ensure an absolute and definite connection, and the horizontal surfaces of the degrees were finished in granolithic.

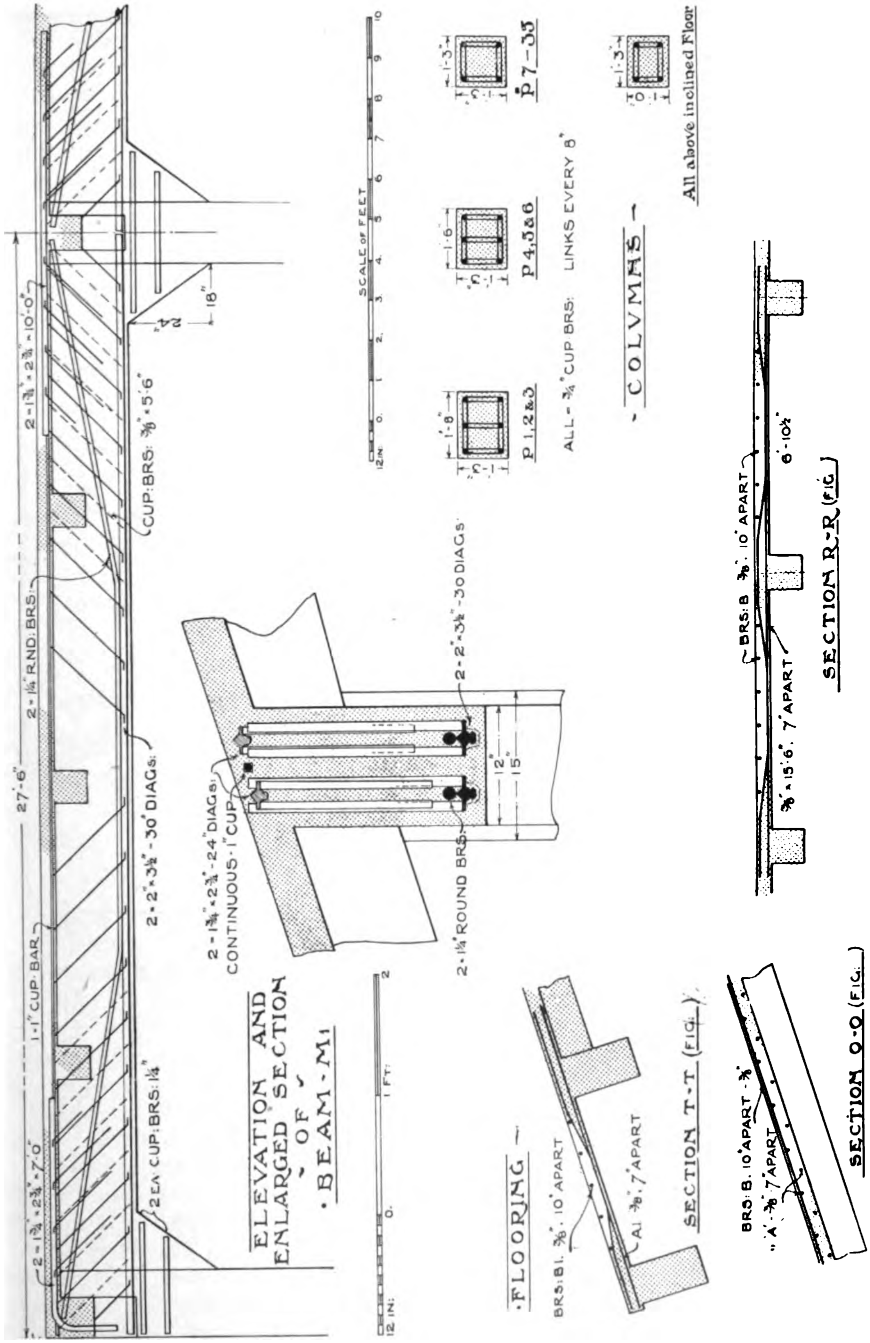
The calculations for the design of the structural details of this work were based



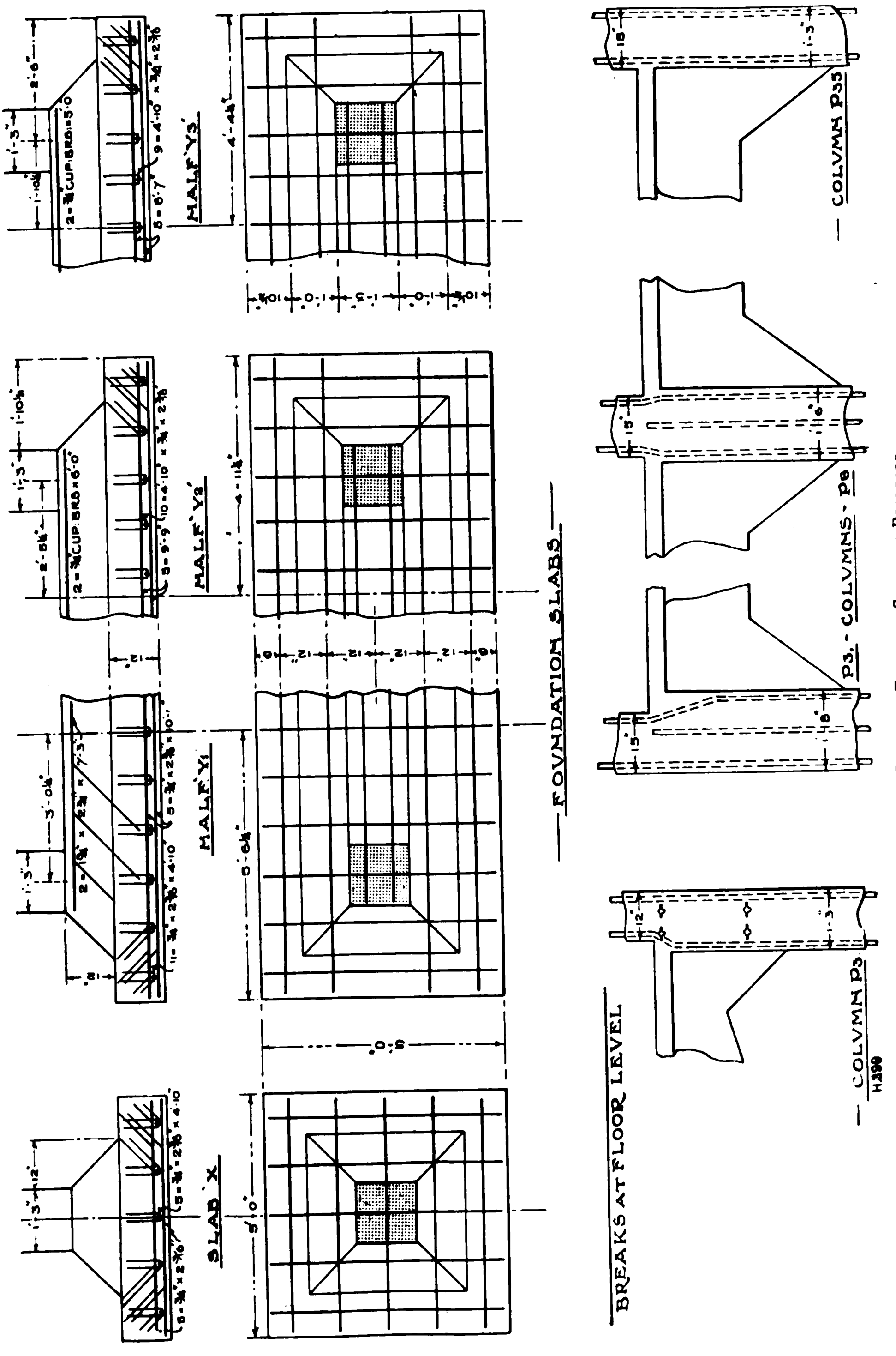
Reinforced Concrete Football Stand at Bradford.
General and Skeleton Plans showing Reinforcements.



Reinforced Concrete Football Stand at Bradford.
General Sections



Reinforced Concrete Football Stand at Bradford.
Details of Floors, Columns and Beams.

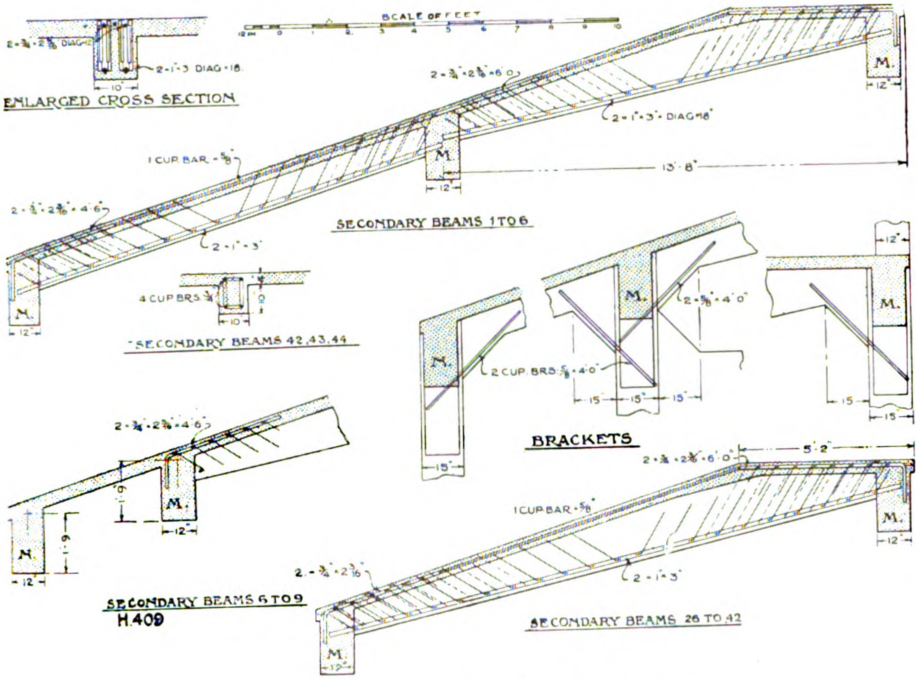


Reinforced Concrete Football Stand at Bradford.
Details of Foundations and Columns.

on the superload arising from a densely packed crowd, plus the self weight of the structure and of the concrete degrees, with an ample co-efficient of safety.

Attention may be directed to the extremely efficient design and disposition of the reinforcement for the reinforced concrete beams, ensuring the maximum of stiffness and rigidity. The designers have introduced a number of horizontal, longitudinal, and transverse struts at different levels for bracing the pillars together. All these struts have been designed as "symmetric" beams.

It will be observed that no diagonal struts have been introduced, this being avoided by the pillars being designed of sufficient strength to meet any lateral stresses, which may be developed in their free lengths. In this way not only has full benefit been taken of the economic advantages of reinforced concrete construction, but also it may be possible to utilise the under portion of the stand at some future date.



Reinforced Concrete Football Stand at Bradford.

Details of Beams and Brackets.

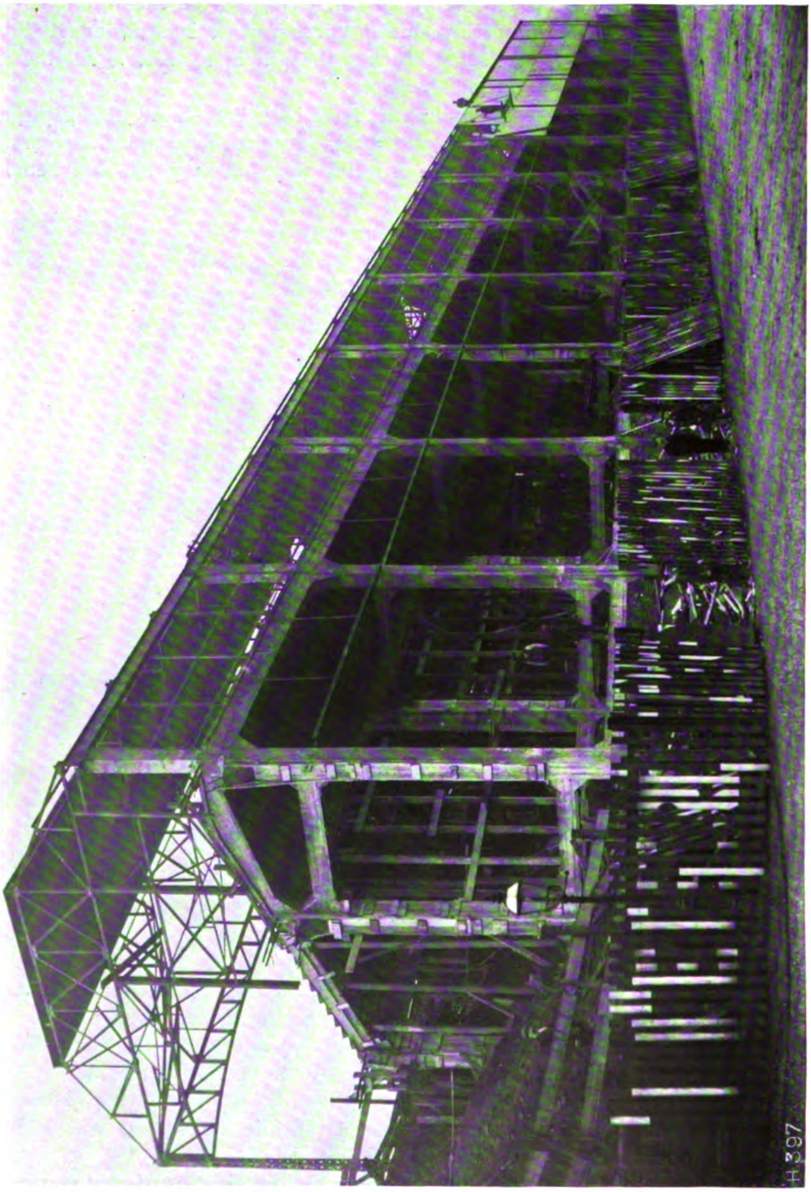
The back of the stand having been left entirely open underneath for the present affords a most striking example of reinforced concrete open framework.

The contractors responsible for the execution of the work were Messrs. John Ellis & Sons, Ltd., of Leicester, and the steel reinforcement used was supplied by The Trussed Concrete Steel Co., Ltd., of London.

We reproduce from the working drawings, kindly lent us for this purpose by Messrs. F. A. Macdonald & Partners, details showing the structural members and method of reinforcement.

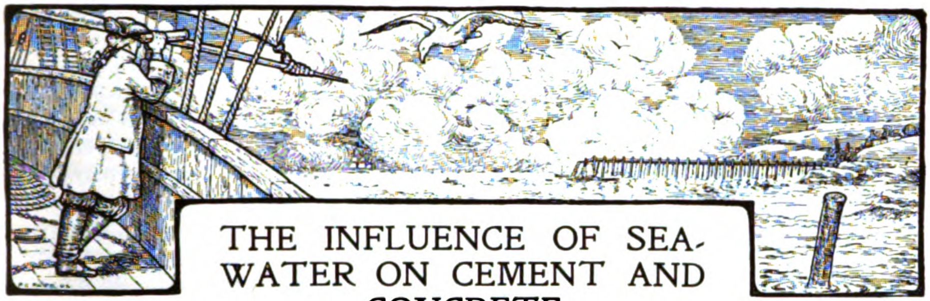
The work was carried out to the plans of the architect, Mr. Archibald Leitch, M.I.Mech.E.

The cement used was the "Ferrocrete" brand, supplied by The Associated Portland Cement Manufacturers (1900), Ltd.



Reinforced Concrete Football Stand at Bradford.
View nearing completion.

The detail designs and drawings for the reinforced concrete work from which the work was executed were supplied by Messrs. F. A. Macdonald & Partners, consulting engineers, 135 Wellington Street, Glasgow.



THE INFLUENCE OF SEA-WATER ON CEMENT AND CONCRETE.

Apart from the excellent papers presented on the occasion of the meeting of the International Commission on Reinforced Concrete at Copenhagen a number of very valuable pamphlets were distributed, among which were two on the problem of the influence of sea-water on cement and concrete which call for special attention. The Danish paper on the subject was by Mr. A. Poulsen and the German report was issued by the Association of German Portland Cement Manufacturers, from which summaries have been prepared for us by Mr. Cecil H. Desch, D.Sc., and we are indebted to the firm of Julius Springer, Berlin, for our illustrations.—ED.

THE question of the changes undergone by cement mortars and concretes in contact with sea-water, of such enormous importance in connection with the construction of docks, harbours, and coast protection works, has been investigated by many workers, prominent among whom is Le Chatelier, without leading to entirely conclusive results. Systematic tests of this kind necessitate considerable organisation, as it is not sufficient to immerse laboratory specimens in vessels containing sea-water, but the actual conditions prevailing in coast constructions—rise and fall of tides, exposure to air and frosts, variations in temperature, etc.—must also be taken into account. The results of two very extensive and systematic series of tests have just been published almost simultaneously, with the effect of adding materially to our knowledge.

REPORTS OF TESTS.

The first series is due to the initiative of the Scandinavian Portand Cement Manufacturers, with the co-operation of the harbour authorities. The report, drawn up by the Chairman of the Committee, Mr. A. Poulsen, was presented to the International Association for Testing Materials at its recent Congress in Copenhagen. The second series forms a part of the extensive researches in connection with cement undertaken by the great German testing station at Gross-Lichterfeld, near Berlin, and is drawn up by Prof. Gary and Mr. C. Schneider, and published in the Bulletin of that institution. Both series of tests have been conducted over a period of ten years. The Scandinavian results are perhaps the more interesting of the two in respect to the light they throw on the conditions prevailing in practice, although the climatic conditions are rather more severe than are usually encountered in this country.

SCANDINAVIAN TESTS.

The Scandinavian scheme embraced the testing of cubes of mortar, and of concrete blocks prepared with the same mortar, over periods extending to 20 years, of which ten have now expired. Four Portland cements were selected for the mortars, one each coming from Norway, Sweden, Denmark, and England. The hydraulic lime of Teil, which enjoys a certain reputation for marine work on the Mediterranean coasts, was also included in the series. For the concrete blocks the same cements were at first used, with the subsequent addition of six more Scandinavian Portland cements, and of mixtures of cement with Rhenish trass, Danish infusorial earth, Santorin earth, puzzolana, slag cement, etc. The sand and ballast were taken from the beach on the west coast of Jutland, and consisted of practically pure quartz and flint.

Testing Cement Cubes.—The cement cubes were placed in sea water at Esbjerg, the most southerly North Sea harbour in Denmark, and at Vardö in the Arctic Ocean. At each of these places two similar sets were placed, one between tide-marks, so as to be alternately covered and exposed twice in each 24 hours, the other at such a depth as to remain submerged even at low tide. A fifth set was placed below tide-level in the harbour of Degerhamn on the Baltic, where the water has only one-seventh the salinity of that of the North Sea. From each cement four cubes were prepared with sand in the proportion 1 : 3, four of 1 : 2, four of 1 : 1, and one of neat cement, or 13 in all. This scheme being repeated with each of the five cements gives 65 blocks, to which must be added 12 cubes prepared with one of the cements and coast sand instead of the usual "normal sand," making 77 cubes as the total of each set. As the tests were to be carried out in the five different situations named above, and the cubes were to be crushed at intervals of 3 months, 6 months, 1, 2, 4, 6, 10, 15 and 20 years, this involved the making of $77 \times 5 \times 9 = 3{,}465$ test cubes. The results obtained from cubes exposed for less than a year proved to be irregular and of little value, and in any future scheme of the same kind it would be well to omit the short-period tests, and to provide for the extension of the long-period test to 30 years.

Testing Concrete Blocks.—Over 100 concrete blocks, mostly 2 ft. 4 in. × 2 ft. × 4 ft. 8 in., but occasionally of half that size, have been prepared, and built up to form a groyne at Thyborön, on the west coast of Jutland. Compression tests on the blocks after exposure being impracticable, the testing was confined to a simple inspection of the blocks after determined intervals and the occasional chemical analysis of fragments. Each block was furnished with a galvanised iron lifting bolt and number plate, and in addition to this coloured beads and small pieces of broken coloured glass were incorporated into the concrete during mixing, the colour of the beads indicating the proportions in the mixture, and the colour of the glass the kind of cement used. By this means even a broken fragment of a block could be identified. The blocks were mixed by hand, and kept moist for four weeks before putting in place.

Results.—In considering the results, it is necessary to bear in mind the conditions of the test. The cubes and blocks placed between tide-marks were exposed at each ebb to the influence of the sun, and in winter of frost, the latter factor being especially prominent at Vardö. The disintegrating effect of such alternations of saturation, drying, and freezing is very great, and these are the conditions to which breakwaters, groynes, and marine embankments are continually exposed, particularly in northern latitudes. To these influences must be added, in many instances, the abrasive action of drifting sand.

To take the mortar tests first, the results showed very little difference between the three Scandinavian cements. The solitary English Portland cement used was unfortunately not a good specimen, as it disintegrated completely under the boiling test, and gave throughout lower crushing results than the other cements. There was very little difference between mortars made with normal sand and with shore sand. The effect of repeated freezing is disastrous, the only specimens capable of resisting the exposure between tide-marks at Vardö being the richest (1 : 1) Portland cement mortars. The Teil hydraulic lime proved to be, in its strongest mixtures, only equal to the weakest cement mortars, and was particularly weak when exposed to frost. That hydraulic lime stands well in the Mediterranean is to be attributed to the absence of frost and also of tidal rise and fall.

The chemical action of sea-water on cement appears to be less marked than has been generally supposed. A good cement shows comparatively little chemical change after 10 years' exposure, beyond an increase in the proportion of chlorides. Neither the magnesia nor the sulphates show any marked increase. On the other hand, the poorer mixtures of hydraulic lime show a great loss of lime and replacement by magnesia and sulphates. Much seems to depend on the compactness of the mortar; a thoroughly dense mixture only allows diffusion to take place so slowly that the effect is almost negligible after several years. A loose mortar, by allowing salts to penetrate to the interior of the mass, is rapidly disintegrated.

Turning now to the concrete blocks, the arrangement of these in the groyne is seen in *Fig.* 1. A few blocks were dislodged by storms and so damaged, but this accident did not materially affect the results. The first lesson of the tests is, that a sufficiently rich mortar should always be used, as blocks made with a 1 : 3 mortar almost always disintegrated, whilst the 1 : 2 mortar is sufficiently strong, at least as far as can be judged by the 10 years' tests. Any good Portland cement appears to be suitable, the chemical composition undergoing little change beyond an increase in the magnesia and sulphates. The blocks made with hydraulic lime suffered badly. A mixture of sands of different fineness is advantageous, although, rather curiously, the best results were not given by the closest mixtures, but by concretes containing an excess of very fine sand. The addition of very finely ground trass or sand to the cement gave better results in some cases, whilst other mixtures, especially those containing infusorial earth, gave very inferior results.

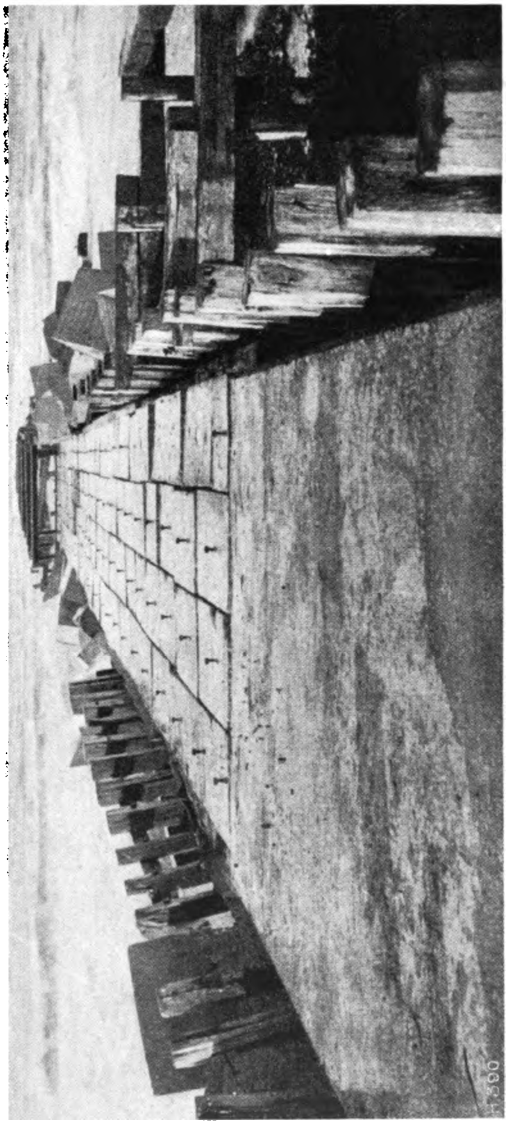


Fig. 1. Concrete Blocks in Groyne at Thyborön.

Two special forms of blocks were also tested, namely, those made by Kinipple's method, by which pure cement and water is forced down into a mould containing the aggregate, without any sand, immersed in the sea, and hollow reinforced Monier

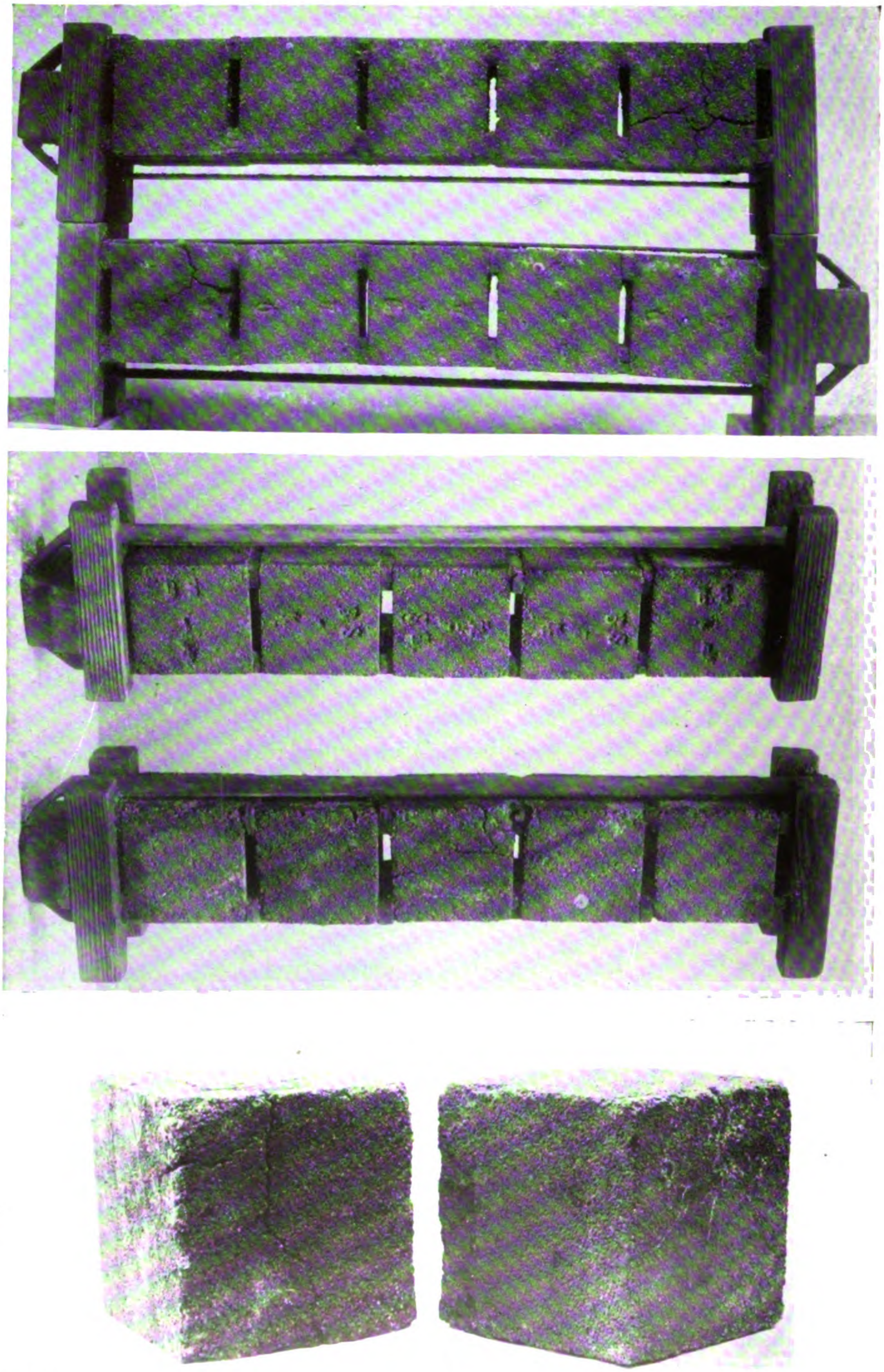


FIG. 2. GERMAN TESTS.
Appearance of blocks after exposure to sea-water.

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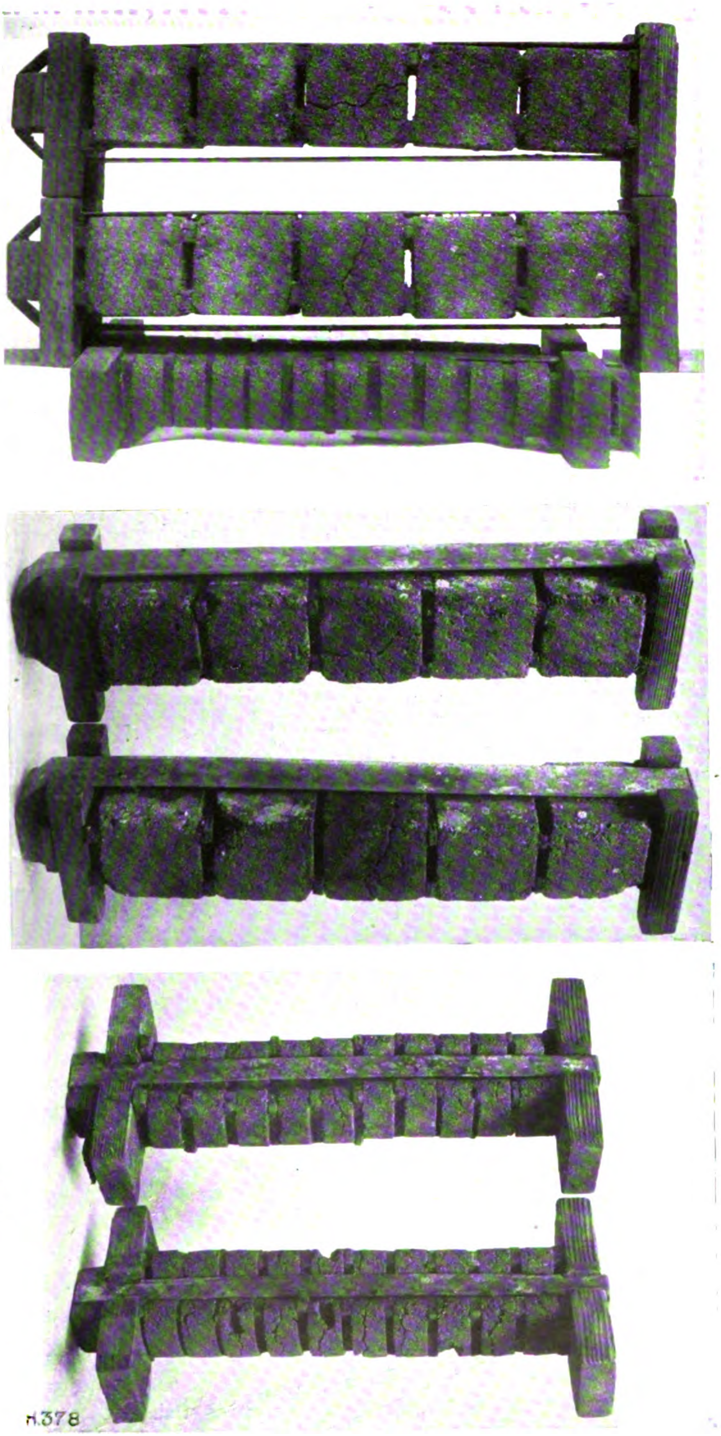


No. 4.

No. 5.

No 6.

Fig. 3. German Tests.
Appearance of blocks after exposure to sea-water.

blocks. Both stood the test well, but cost and resistance to the impact of drift timber, etc., are factors which have to be taken into account in determining their value.

GERMAN TESTS.

The German tests were conducted at the laboratory of the Association of German Portland Cement Manufacturers at Westerland, which was reconstructed and enlarged for the purpose. The concrete and mortar cubes and the tensile test pieces were immersed in two tanks, containing fresh and salt water respectively. The large concrete blocks for exposure to the tides were allowed to remain in moist sand for three months in some cases and one year in others before transferring to their places in the groyne, where they were covered and uncovered at each rise and fall of the tide. As in the Scandinavian tests, each block was provided with a galvanised iron lifting bolt.

Two German Portland cements were used in the final experiments, one of which was richer in lime than the other. The addition of finely-ground trass was also included in the experiments, as well as the use of mortars composed of lime and trass. All mortars and concretes were mixed in a machine, and rammed in moulds, and comparative tests showed that hand mixing, at least in the case of mixtures of lime and trass, gave results distinctly inferior to those obtained by machine mixing.

The mortars richest in cement in all cases resisted exposure to sea-water best. As regards trass, its addition to the cement lowers the initial strength, but causes hardening to take place more rapidly, so that mortars containing trass gain rapidly in strength when stored in fresh water, but in sea-water the action, so far as tensile tests are concerned, is the reverse, the trass mixtures starting well, and then falling off in quality. It is not possible to decide this point quite definitely until more of the long-period tests have been completed. The two cements used were very unequally affected by the addition of trass. Throughout the tests cement A, containing 65·9 per cent. of lime, behaved better than cement C, which contained only 62 per cent. and was high in alumina, but it is not certain that the difference is to be ascribed solely to the lime content, as the mode of combination of the constituents may have been different, and the difference in the proportion of aluminates must have had a great effect on the cements.

The influence of the various factors appears more clearly in the behaviour of the concrete blocks in the groyne than in that of the smaller blocks in the tanks. Nearly all the blocks made with cement C developed cracks, whilst those made from cement A resisted well, especially when made with the richer mortars. Poor mortars, but not rich, were improved by the addition of trass. Blocks allowed to harden for a year in moist sand invariably resisted better than blocks only allowed to harden for three months. Mixtures of trass and lime, if rich in lime, became abraded by the action of drifting sand, but did not disintegrate, whilst poor mixtures scaled off. Lime in powder gave slightly better results than when added to the mixture as a cream.

General Appearance of Blocks.—The general appearance of the small blocks after exposure to sea-water is seen in *Figs.* 2 and 3, which represent the following mixtures:

No. 1 in *Fig.* 2.—Compression blocks, 1 cement : 4 normal sand, after 5 years.

No. 2 in *Fig.* 2.—Compression blocks, 55 cement : 45 fine sand : 400 normal sand, after 6 years.

No. 3 in *Fig.* 2.—The middle blocks of *Fig.* 3, removed from their frames.

No. 4 in *Fig.* 3.—The same mixture as in *Figs.* 3 and 4, but with a somewhat different cement, after 5 years.

No. 5 in *Fig.* 3.—The same series, after 6 years.

No. 6 in *Fig.* 3.—The tensile test-pieces of the same series, after 6 years.

The size of the mortar cubes for compression was 50 sq. cm. surface (approximately 3 in. side). The "fine sand" and trass were ground to pass a sieve with 900 meshes per sq. cm. (75 per linear inch), and were thoroughly incorporated with the cement by grinding before mixing. The concrete cubes for compression were of 12 in. side.

A word may be said as to the wooden frames used in holding the cubes in place during the sea-water tests. The German tests, being conducted in a tank into which the sea-water was pumped, did not call for any special arrangement, and the simple frames shown in *Figs.* 2-3 seem to have proved quite satisfactory. In the Scandinavian experiments, however, the presence of *Toredo* and other wood-boring crustacea in the harbours of Esbjerg and Vardö made special precautions necessary. Deal frames could only be used for the shortest period tests. For others, oak frames, strongly bolted together, 12 ft. 8 in. long, each capable of holding 80 cubes, were used. At Vardö, even these were attacked, and it was found necessary to construct the cases of Australian greenheart, which is practically unattacked by crustacea.

CONCLUSIONS.

As far as it is possible to draw definite conclusions at present, the following may be said to be the principal results of the two series of experiments:

1.—Good Portland cements, such as are now on the European market, are very resistant to the action of sea-water. A marked difference in the behaviour of cements of slightly different composition has not been found, except that a high proportion of aluminates tends to cause disintegration.

2.—In a dense mortar, the chemical action is confined to an outer layer of small depth, further action being checked by the slowness of diffusion. A porous mortar, by admitting salt water to the interior, is apt to crack by expansion owing to chemical change.

3.—The main agency in the destruction of mortar and concrete in marine embankments, harbour works, groynes, etc., is not chemical action, but the alternations of saturation, drying in the sun, freezing, etc., due to the alternate exposure and covering by the rise and fall of the tide. Destruction takes place sometimes by cracking, sometimes by scaling, the latter effect being produced especially by frost.

4.—The denser the mortar the better (1 cement : 3 sand is too poor). An admixture of fine sand with the ordinary sand increases the closeness of the mixture. A well-graded aggregate would be advantageous for the same reason.

5.—The addition of finely-ground silica or trass to the cement before mixing is possibly advantageous in the case of weaker mortars. It is very doubtful whether anything is gained by adding trass to the richer mortars.

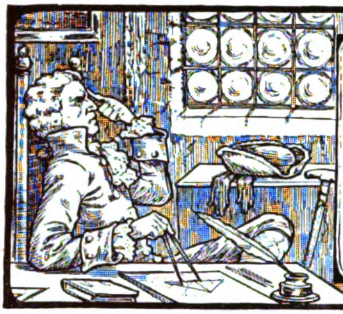
6.—Hydraulic lime mixed with trass, etc., whilst of some value, where a cheap material is required, in the mild climate and absence of tide of the Mediterranean, is incapable of withstanding the conditions of coast work in northern latitudes.

7.—The destructive action of the sea being mainly physical and mechanical, and not chemical, tests by mere immersion in still sea-water are of very little value in determining the behaviour of concrete in marine engineering works. A mixture which disintegrates under this test is certainly useless, but a mixture which passes the test may disintegrate under the more stringent conditions of practical use.

8.—As long a period as is practicable should be allowed for the hardening of concrete blocks before placing in the sea. The German recommendation of one year in moist sand before setting in place is probably impracticable in most places, but should be approached as nearly as possible.

9.—The behaviour of test-specimens for the first 12 months is very irregular, and definite conclusions can only be drawn from the results of long-period tests.

Both of the reports contain very full tables of crushing and tensile tests, and a complete record of the appearance of each concrete block at stated intervals.



THE CONCRETE INSTITUTE

PROPOSED STANDARD NOTATION FOR CALCULATIONS IN REINFORCED CONCRETE WORK.

The communication on the proposed standard algebraical notation for the calculation of reinforced concrete work transmitted to us by the Concrete Institute is, in our opinion, one of the utmost importance to the members of the technical professions in English-speaking countries, and we thus publish the communication with its enclosure in full, and shall be pleased to give later on any comments we receive on the subject.—ED.

THE Science Committee of the Concrete Institute, which has been doing such excellent work under the chairmanship of Mr. William Dunn, F.R.I.B.A., Mr. F. E. Wentworth-Sheilds, M.Inst.C.E., acting as Hon. Secretary, is mainly responsible for the communication we publish below on the question of a standard algebraical notation for calculations in reinforced concrete work.

The Institute, and its Science Committee in particular, are to be congratulated on this painstaking piece of work, in which, we believe, Mr. E. Fiander Etchells, F.Phys.Soc., M.Math.A., has been an active and enthusiastic pioneer If the Institute in this early period of its life can produce contributions to our national and even international co-ordination of technical problems, it is certainly doing praiseworthy work, and is rapidly proving the utility of its existence.

The communication we have received reads as follows :—

1 Waterloo Place, Pall Mall,
London, S.W.
18th December, 1909.

SIR,—I am desired by the Council of the Concrete Institute to forward you copies of a proposed standard notation for formulæ employed in reinforced concrete work.

In 1909 the Council, having regard to the confusion arising from the many various symbols used for the same quantity by scientific writers and the advantages of an agreement on a standard notation, referred the matter to its Science Committee. This Committee was later requested to consider the proposal for a standard notation received from the International Commission on Reinforced Concrete (founded by the International Association for Testing Materials).

The Science Committee resolved :—

1. That the "Three-alphabet" system adopted by the International Commission, consisting of capital Roman letters, small Roman letters, and small Greek letters, be approved.

2. That the principle of the initial letter, *i.e.*, the use of initials or distinctive self-explanatory letters of the governing words that were employed as a general rule for abbreviations, should be adopted.

3. That the desired uniform mathematical notation for the most important magnitudes occurring in the specifications and statical computations should be drawn up, so as to be in harmony as far as possible with the language in which such specifications were written or made.

A Sub-Committee consisting of Professor Adams, Mr. W. Dunn, Mr. E. F. Etchells, Mr. J. E. Franck, and Mr. C. F. Marsh was then appointed to prepare a draft report, which was considered by the whole Committee, and after some modification was eventually adopted.

Copies of this draft report were sent to Professor Melan, and were considered by a Committee of the International Commission on Reinforced Concrete at Copenhagen in September of this year.

It was found that the principle of the initial letter formed an obstacle to agreement with continental nations.

For instance, in England and America *d* would be used as a contraction for depth and *b* as a contraction for breadth, but the contractions of the French words " hauteur " and " largeur " would give us *h* and *l*. Again, on the Continent, Greek smalls are used for intensity of stresses.

The American and English delegates to Copenhagen (Professor Talbot, of Illinois, U.S.A., and Mr. William Dunn, Chairman of the Science Committee of the Concrete Institute) were of the opinion set out in the report, viz. :—That it would be difficult to induce the English-speaking peoples to adopt the Continental practice in respect of the use of Greek letters for tensile, compressive, and shearing stresses.

It was felt that such a general agreement as is embodied in the resolutions of the Science Committee previously drafted is all which could be hoped for at present, and that the English-speaking peoples should endeavour to agree on a standard notation for their own use, based on the abbreviation of English words.

Copies of these proposals of the Concrete Institute have been sent to the British and American Societies concerned.

You will, I am sure, realise that if such a list could be adopted by the American and English nations it would be an immense boon to both.

I am, sir, yours very truly,
ARTHUR E. COLLINS, Hon. Secretary.

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

[*DRAFT COPY*

DRAFT REPORT OF THE SCIENCE STANDING COMMITTEE.

PRINCIPLES ADOPTED.

Algebraical notation in engineering formulæ should be simply a species of shorthand in which one letter stands for a word or phrase.

This species of shorthand should have a logical basis, should be self-explanatory, and should not tax the memory.

The simplest and most natural system is to abbreviate the significant words to their fullest extent. For example, successive abbreviation of longhand would give us in turn such forms as *diameter, diam, dia,* and finally *d.*

This principle of the initial letter, or distinctive *self-explanatory* letters, has been adopted with great success in chemistry and in ordinary daily life, in titles and the names of institutions, etc.

It may be urged that by the adoption of successive abbreviation confusion may arise, but the risk of confusion is lessened by classing our quantities into definite groups and taking advantage of the differences between capital and small letters.

The risk of confusion is reduced to a minimum by the adoption of what is known as the three-alphabet system.

THREE-ALPHABET SYSTEM OF NOTATION ADAPTED TO THE ENGLISH LANGUAGE.

Latin Smalls.	Latin Capitals.	Greek Smalls.
Lineal dimensions (lengths and distances, etc.)	Areas and volumes	—
—	Moments	—
Intensity of forces	Total forces	—
Intensity of loads	Total loads	—
Intensity of stresses	Total stresses	—
—	Angles	Angles
Constants, etc.	Constants, etc.	Constants, etc.

It should be borne in mind that this table is practically in accord with existing English and American practice, except that the vagaries and inconsistencies have been eliminated as far as possible.

For some years now there has been an unconscious drifting towards some such classification as that now definitely formulated.

The consistent adoption of the three-alphabet system and the initial letter system would lift the problem of a standard notation out of the realm of personal bias and place it on a broader basis.

Attention is invited to one of the great advantages brought about by the frank acceptance of the three-aphabet system; for instance, in dealing with bending moment the fact that it is a moment is sufficiently indicated by the use of capitals, so that we can have the two single symbols—

B = Bending moment of the external forces.
R = Resistance moment of the internal stresses.

Now, if we use M_B for Bending moment we cannot easily with a simple practical symbol discriminate between:

1. Bending moment a' any distance X from the left support.
2. Bending moment at the centre of a beam.
3. Bending moment at the end of a beam with fixed ends.

If, however, we use B to represent bending moments, we get the following brief, simple, and *self-explanatory* reductions:

B = Maximum bending moment on a beam.
B_X = Bending moment at the distance X from the left support.
B_C = Bending moment at the centre of a beam.
B_E = Bending moment at the end of a beam with fixed ends.

Moreover, if B be used instead of the more usual BM or M_B we get the following consistent series:

B = Bending moments on beams.
I = Inertia moments.
M = Moments in general (or Mass moments in dealing with dynamical problems).
O = Overturning moment.
S = Stability moment.

NATURAL LIMITATION OF STANDARDISATION.

It has been suggested that a Universal Standard Notation for all branches of engineering and for all languages should be adopted, but this is impossible for the following reasons: Confining ourselves to the Latin and Greek alphabets, we have a total of about 100 letters, but we must deduct about 33 of these on account of the risk of confusion. We have thus 67 symbols left.

Now, in the various branches of engineering there are many hundreds of terms embodied in equations in some form or other and only 67 symbols to represent them.

It should be obvious, therefore, that in the various branches of engineering the same symbols must have different meanings.

Again, an international system of notation would not appear suitable for daily national use, for in so far as it were self-explanatory to the English-speaking peoples, so far would it be a matter of memory to the other nations, and *vice versâ*.

An artificial and arbitrary notation devised by savants for international use could not hope to obtain the unanimous support of any nation, for a polyglot notation would be more of a hindrance than a help to the majority in any country.

It is suggested that notation should follow the language of the text, *i.e.*, that French notation should be an abbreviation of French words, and German notation of German words. The three-alphabet system could, of course, be adopted by all nations, though the actual symbols used would be different.

LEGIBILITY OF NOTATION.

If the small Roman letters of the ordinary letterpress on any printed page determine the size of the subscript letters, such as A_C or t_c, etc., it will follow that the subscript letters, being from a smaller fount, may be too small to be easily legible.

It is, therefore, recommended that all our symbols be set in large type, so that the subscript letters may be reasonably clear and unmistakable.

It is also suggested that the Latin smalls should be in italics and the Latin capitals in upright letters, so as to help to discriminate between *c, s, w, v* and C, S, W, V, etc.

LIST OF SYMBOLS.

The acceptance of the above broad principles will do much to build up a natural standardisation, to which all writers will gravitate, with the assurance that any new symbol they may be compelled to introduce will be certain to win its way to general approval, provided that it is consistent with these principles.

The attached list of symbols is not complete, but will be found sufficient to meet the more pressing needs, and will serve as an illustration of the basic principles herein formulated.

SYMBOLS INDEPENDENT OF UNITS EMPLOYED.

The notation has been drafted so as to leave the symbols independent of the magnitude of the various units.

For example, p represents intensity of pressure, whether that pressure be measured in pounds per square inch or tons per square foot, or even in kilogrammes per square centimetre.

As this notation does not vary according to the magnitude of the units employed, and as every author has his own opinion as to what units are most suitable for any given case, it is necessary for authors to specify in every case what units they employ. For example, according to circumstances, w may represent—

Weight per unit of length; weight per unit of area; weight per unit of volume.

ELASTICITY OF THE NOTATION.

A great number of the symbols—such as those for length and height, etc.—have been left in general terms. Before using any of these it will be necessary to specify definitely between what points such lengths or heights are to be measured.

METHOD OF PRESENTATION.

It is suggested that the tax on the memory would be greatly reduced if the author would give his notation at the beginning of the book or in close proximity to the equations.

HOSPITALIER NOTATION.

In specifying the units employed the following abbreviations may be used:

Inches = ins.
Feet = ft.
Cubic inches = ins.^{3}.
Pounds per square inch = lbs./in.^{2}.
Hundredweights per cub. foot = cwts./ft.^{3}.
Tons per square foot = tons/ft.^{2}.
Etc., etc.

FURTHER CLASSIFICATION OF SYMBOLS.

There are several reasons why this list of symbols should be presented in alphabetical form without any other classification, but in using the symbols in books it will probably be found more satisfactory to divide the symbols into groups such as, symbols for pillars, for beams, rectangular and tee-sections, etc., etc.

They can be readily memorised if classified, but such grouping should depend upon the needs of the author and the reader.

THE CONCRETE INSTITUTE.

LIST OF SYMBOLS

(Suggested by the Science Standing Committee.)

(Subject to Revision; and also subject to Approval by the Council of the Concrete Institute.)

LENGTHS, DISTANCES, INTENSITY OF LOADS, STRESSES PER UNIT OF AREA, AND CONSTANTS.

a	*Arm* of any couple, *i.e.*, distance between two parallel forces of equal magnitude, but acting in opposite directions.
a	*Arm* of the couple formed by the compressive and tensile forces in a beam.
b	*Breadth.*
b	*Breadth* of a rectangular beam parallel with neutral axis.
b_r	*Breadth* of the *rib* in a tee-beam.
b_s	Effective *breadth* of the *slab* in a tee-beam.
c	*Compressive* stress intensity.
c	*Compressive* stress intensity on concrete.
c_s	*Compressive* stress intensity on *steel.*
	In Rectangular Sections :
d	*Depth.*
d	Effective *depth* of a beam from top of beam to axis of tensile reinforcements.
d_t	*Total depth.*
d_s	Total *depth* of a *slab* in a tee-beam.
d_c	Depth or *distance* of the centre of *compression* reinforcement from the compressed edge.
	In Circular Sections.
d	Any *diameter.*
d	Internal *diameter.*
d_o	*Outside diameter.*
d_c	*Diameter* of the *core* of a pillar with helical reinforcements.
d_l	*Diameter* of a *longitudinal* reinforcing rod of a pillar.
d_h	*Diameter* of a *helical* reinforcing rod in any compression piece.
d_n	*Deflection* of a beam.
e	*Eccentricity* of any load.
f	*Friction* or adhesion between surfaces in units of force per unit of area.
g	*Gravity* coefficient, *i.e.*, the acceleration due to gravity.
h	*Height.*
h	In pile work : *height* from which the ram falls.
l	*Length.*
l	Effective *length* or span of a beam or arch.
l	In pile work : *length* of pile.
m	*Modular* ratio, *i.e.*, the ratio between the elastic moduli of steel and concrete $= E_s/E_c$.
n	In beams : distance of the *neutral* axis from the compressed edge of a beam.
$\frac{n}{d}$	The ratio n/d, *i.e.*, the distance between the *neutral* axis and the compressed edge divided by the effective *depth* of a beam.
p	*Percentage* of steel, *i.e.*, $p = 100r$.
p	Intensity of *pressure* per unit of length or area in any direction.
p_h	Intensity of *horizontal pressure.*
p_v	Intensity of *vertical pressure.*
p_t	Intensity of *tangential pressure.*
p_n	Intensity of *pressure normal* to any given surface
r	*Radius.*
r	*Ratio.*
r	*Ratio* of area of steel to area of concrete in singly reinforced beams (compare p).
r_t	*Ratio* of area of steel in *tension* to area of concrete in doubly reinforced beams.
r_c	*Ratio* of area of steel in *compression* to area of concrete.
s	*Shearing* stress intensity.
s	*Shearing* stress intensity on concrete.
s	In pile work : average *set* or penetration of the pile under the final blows.
t	*Tensile* stress intensity.
t_c	*Tensile* stress intensity on *concrete.*
t	*Tensile* stress intensity on steel.
v	*Versine* or camber of a curve or rise of an arch.
w	*Weight* per unit of length.
w	*Weight* per unit of area.
w	*Weight* per unit of volume.
x	Any unknown quantity.
x	The independent variable in any function.
y	A second unknown quantity.
y	Any function of x, such as $y = x^2$, etc.
y	An ordinate corresponding with the abscissa x, *i.e.*, the co-ordinate of x.
z	A third unknown quantity.

AREAS, VOLUMES, MOMENTS, TOTAL LOADS, TOTAL FORCES, AND CONSTANTS.

A	*Area.*
A	Total cross-sectional *area* of a pillar.
A	In pile work: cross-sectional *area* of the pile.
A_L	Cross-sectional *area* of *longitudinal* steel rods in a pillar.
A_H	Cross-sectional *area* of a *helical* reinforcing rod in a pillar.
A_E	*Equivalent area.* (This will require to be specifically defined for each equation in which it occurs.)
A_C	*Area* of *compressive* reinforcement in beams.
A_T	*Area* of *tensile* reinforcement in beams.
A_s	*Area* of *shear* reinforcement in a given length in beams.
B	*Bending* moment.
B	Maximum *bending* moment of the external forces or loads on a beam.
B_X	*Bending* moment at a distance *x* from left abutment.
B_C	*Bending* moment at *centre* of beam.
B_E	*Bending* moment at *end* of beam.
C	Total *compressive* force or stress.
C_c	Total *compression* on *concrete.*
C_s	Total *compression* on *steel.*
E	*Elastic* modulus of any material.
E_C	*Elastic* modulus of *concrete* in compression.
E_S	*Elastic* modulus of *steel.*
F	Total *friction* between any two surfaces.
I	*Inertia* moment.
I_X	*Inertia* moment on axis XX.
I_Y	*Inertia* moment on axis YY.
I_S	*Inertia* moment for *steel.*
I_C	*Inertia* moment for *concrete.*
M	*Moment* of a force or algebraic sum of the moments of several forces.

N	*Normal* force, *i.e.*, force normal to a given surface or plane.
O	*Overturning* moment.
P	Total *pressure* on a given area.
P	In pile work: Actual total *pressure* or load coming upon the pile.
P_T	Total *tangential pressure.*
P_N	*Pressure normal* to a given surface.
P_H	*Pressure (horizontal).*
R	*Resistance* moment of the internal stresses in a beam at a given cross-section.
R_L	*Left reaction.*
R_R	*Right reaction.*
R_1, R_2, R_3, etc.,	*Reactions* on intermediate supports.
R_S	In pile work: *Safe resistance* of the pile to further penetration.
R_U	In pile work: *Ultimate resistance* of pile to further penetration.
S	*Stability* moment.
S	Total *shearing* force across a section.
S_H	Total *horizontal shear* on a given length.
S_V	Total *vertical shear* at any cross-section, when necessary to discriminate.
S_C	Total *shear* taken up by *concrete.*
S_S	Total *shear* taken up by *steel.*
S_F	*Safety factor.*
S_M	*Section modulus.*
T	Total *tensile* force.
T	Total *tensile* stress on a given cross-section.
T_C	Total *tension* on *concrete*, when necessary to discriminate.
T_S	Total *tension* on *steel.*
W	*Weight* or load.
W_R	In pile work: *Weight* of the *ram.*
W_P	In pile work: *Weight* of the *pile.*

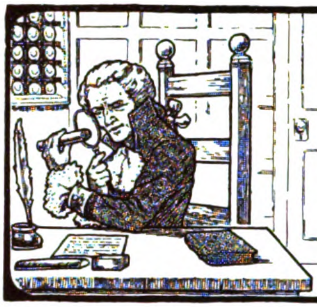
ANGLES, CONSTANTS, AND MISCELLANEOUS.

α or A	Any angle.
β or B	Any angle.
γ or C	Any angle.
θ	Inclination of a line to the *horizontal* plane. (Note the horizontal direction of the line in the symbol. Compare ϕ.)
μ	Moment of resistance modulus in the equation $\mu bd^2 =$ Moment of resistance.

μ	Friction modulus, *i.e.*, the ratio of the tangential to the normal force.
π	The *peripheral* ratio, *i.e.*, the ratio of the circumference of a circle to its diameter.
Σ	*Summation* sign.
ϕ	Inclination of a line to the vertical plane. (Note the approximately vertical direction of the line in the symbol. Compare θ.)
O	Perimeter of any regular or irregular figure.

By order of the Science Standing Committee of the Concrete Institute,

H. Kempton Dyson, *Technical Secretary.*



TESTS ON REINFORCED CONCRETE CONDUCTED IN GREAT BRITAIN.

(PART IV.)

The absence of systematic testing relating to reinforced concrete has placed this country at a disadvantage in the utilisation of this modern material for structural purposes. Excepting only in regard to fire tests, such investigations as have been conducted have been quite spasmodic in character, and practically always of a purely private nature.

Having regard to the fact that the question of a series of tests being conducted in this country, in a systematic manner, is having the attention of the Institution of Civil Engineers, the Concrete Institute, and other scientific societies, we are presenting particulars, as far as we are able, in chronological order, of such tests as have been conducted in this country from time to time, and this may serve as a useful guide to those who have the arrangements of the tests of the future.

The first three articles of this series appeared in our May, September and November numbers respectively. The following particulars of tests are now presented, and further articles will appear from time to time.—ED.

TESTS ON THE HERBST SYSTEM.

Load tests on three reinforced concrete hollow floors on the Herbst tubular system, constructed by the Armoured Tubular Flooring Co., Ltd., of London, were conducted by the British Fire Prevention Committee on January 29th and 30th, June 7th, 8th, and 27th, and July 17th, 1907. The construction of the test floors is shown in *Fig.* 17.

The general particulars of the tests were as follows, and the results are given in the table on page 37.

A mechanical bond bar of corrugated section ribbed across was embedded in each web about 1 in. above the soffit. These webs were made of 2 parts shingle, passing a $\frac{3}{8}$-in. mesh, 1 part sand, and 1 part "Ferrocrete" brand Portland cement. The tubes were made in hand-press machines of 7·5 parts coke breeze, 5 parts sand, and 1 part Portland cement. These tubes were placed between and resting on the offsets on the ribs, and were concreted over with a topping of concrete composed of 1 part Portland cement, 3 parts shingle, passing a $\frac{3}{8}$-in. mesh, the top being trowelled to a smooth surface. The slabs rested 9 in. and 10 in. at each end on York stone templates $3\frac{1}{2}$ in. thick, bedded on short lengths of brick walls 3 ft. 9 in. long, $13\frac{1}{2}$ in. thick, about 1 ft. 9 in. or 2 ft. high above ground.

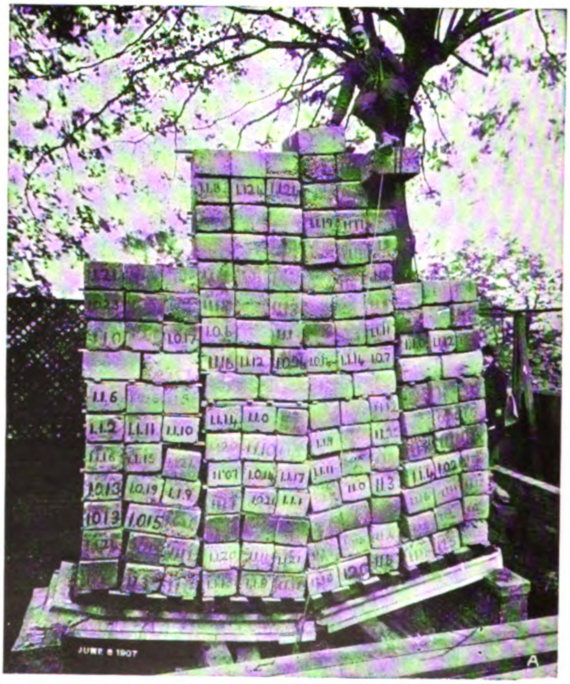


FIG. 16. HERBST SYSTEM TESTS: VIEW IMMEDIATELY AFTER BREAKING.

TABLE X.—TESTS ON THE HERBST SYSTEM.

	Size and Dimensions and Construction	Clear Span	Reinforcement	Age	Loading and Deflections. 5 cwts. per ft. super; deflection, 0·3"										
Slab A	Three Webs: 9½" deep, 3" wide, reduced to 1¾". Tubes: 9½" deep, 8½" wide, and 8" long Topping: 2' 6½" wide and 2¼" thick above top of webs Total Thickness: 11¾"	14 ft.	Wrought-iron corrugated bars 1¾" × $\frac{3}{16}$", one in each web	*Deflection Test*: About 6½ weeks *Breaking Test*: 24½ weeks	Total load in lbs.	25,883	29,377	32,685	36,120	39,628	43,159	45,049	46,920	48,724	49,201
					Load per ft. super in lbs.	729·1	827·52	920·7	1017·4	1116·28	1215·75	1268·99	1321·69	1372·51	1385·95
					Deflection at centre in inches	·72	1·41	1·74	3·36	3·66 Shearing cracks at ends	4·44	4·95	5·85	6·27	Collapsed
Slab B	Three Webs: 13½" deep, 3¾" wide, reduced to 2¼". Tubes: 13½" deep, 8½" wide, and 8" long. Topping: 2' 9" wide and 4¾" thick above top of webs Total Thickness: 18¼"	28 ft.	Wrought-iron corrugated bars, 2¼" × ¼", two in each web	27·3 weeks	Total load in lbs.	23,040	29,968	37,180	44,315	51,544	58,907	65,996	65,996 After 8 days interval	65,996 After another 27 days interval	65,996 After another 14 days
					Load per ft. super in lbs.	299·22	389·19	482·86	575·52	669·4	765·03	857·09	857·09	857·09	857·09
					Deflection at centre in inches	·05	·29	·43	·65	·83	·91 Shearing cracks at ends	1·24	3·66	3·95	Failed
Slab C	Three Webs: 9½" deep, 3" wide, reduced to 1¾" Tubes: 9½" deep, 8½" wide, and 8" long Topping: 2' 5½" wide and 2¼" thick above top of webs Total Thickness: 11¾"	14 ft.	Wrought iron corrugated bars, 1¾" × $\frac{3}{16}$", one in each web	27·3 weeks	Total load in lbs.	22,630	24,380								
					Load per ft. super in lbs.	65,594	706.67								
					Deflection at centre in inches	—	·25	Slab suddenly collapsed							

The load was applied by means of blocks of concrete, each about 18 in. by 12 in. by 9 in., each being weighed, and the weight marked on it. Care was taken to prevent arching of the load, the arrangement of loading being as shown in *Figs.* 16 and 18.

TESTS WITH TRUSSED BARS.

The following are particulars of tests on various constructions in which the "Kahn" bar was employed, chiefly as a reinforcement, by the Trussed Concrete Steel Co., Ltd.

The test conducted for the Bank of England was on beams and slabs. It will be seen from the diagram that the floor slab was supported by main beams and a wall, and in the centre by a subsidiary beam, 15 ft. 9 in. span, 12 in. wide by 20 in. deep, reinforced with two 1¼ in. trussed bars. The allowable deflection of the beam was specified not to exceed $\frac{1}{250}$ of the span —*i.e.*, $\frac{1}{250}$ by 189= ¾ in., with a load of 450 lb. per ft. super. The decking slab was 5 in. thick, reinforced with ½-in. trussed bars spaced 12 in. centre to centre.

As regards the material used, the aggregates consisted of crushed Thames ballast and sand, while the cement was of the "Ferrocrete" brand. Two parts of the ballast were mixed with 1 of sand, and 5 parts of the final mixture were mixed with 1 of cement, so that the proportions of the concrete were 3⅓ ballast, 1⅔ sand to 1 of cement. The age of the floor at the time of the test was 67 days.

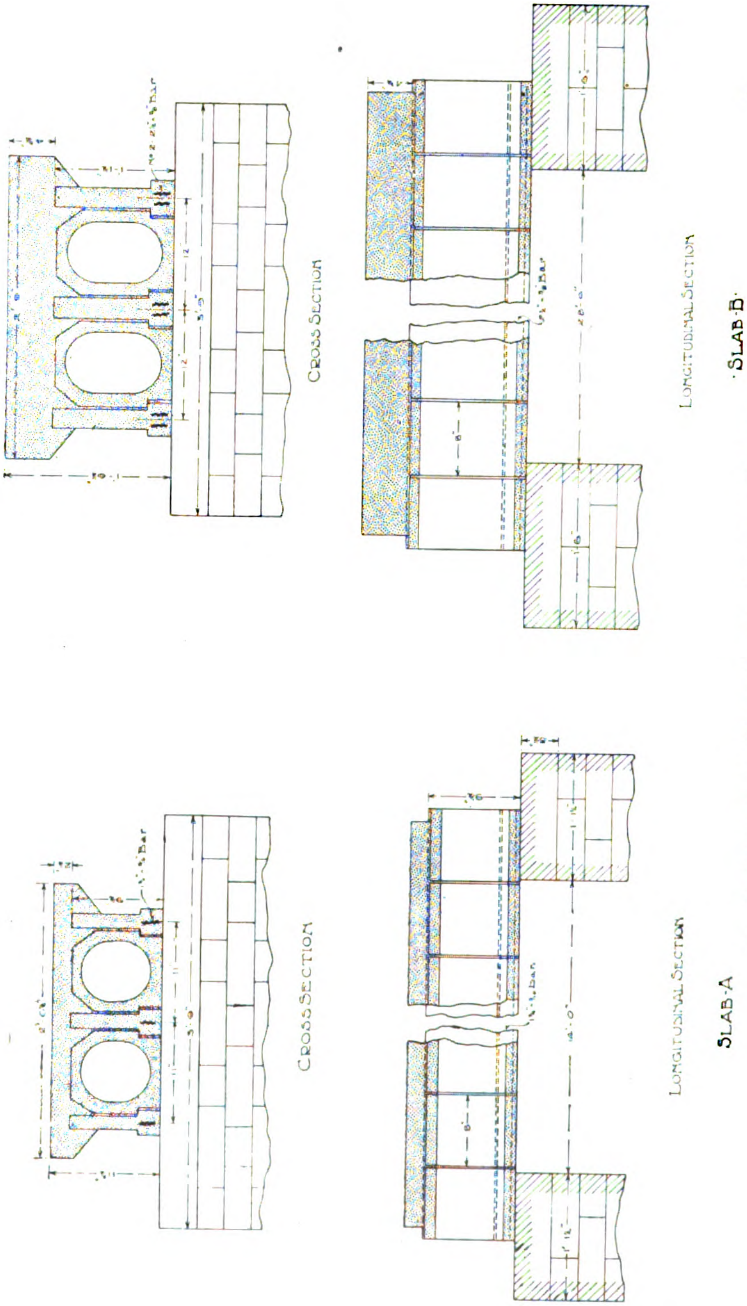


Fig. 17. Tests on the Herbst System. Details of Construction.

The load was applied by means of bricks piled upon an area measuring 15 ft. 9 in. by 13 ft. = 204¾ sq. ft. Deflection was taken at two points—namely, one at the centre of the subsidiary beam in the centre of the floor slab, and the other at the centre of the end main beam. These two deflectometers consisted of levers which, in recording, multiplied by ten the actual deflections of the beams. The deflection of the subsidiary beam was obtained by deducting from that registered by its deflectometer the amount of the deflection shown by the deflectometer under the main beam.

The slab was first loaded with 300 lb. per sq. ft., for which it was designed. This load produced practically no deflection in the secondary beam. Eventually a load of 125,290 lb. was evenly distributed over the area, giving a load of 612 lb. per ft. super. The deflection was ascertained to be $\frac{1}{8}$ in. As the clear span of the beam was 15 ft. 9 in.—189 in.—the deflection was, therefore, $\frac{1}{8}$ by $\frac{1}{189}$ = $\frac{1}{1512}$ part of the span.

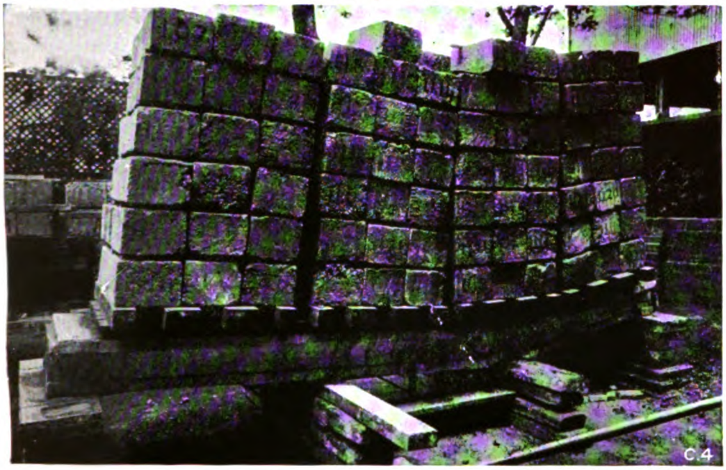


Fig. 18. Herbst System Tests: View after Test.

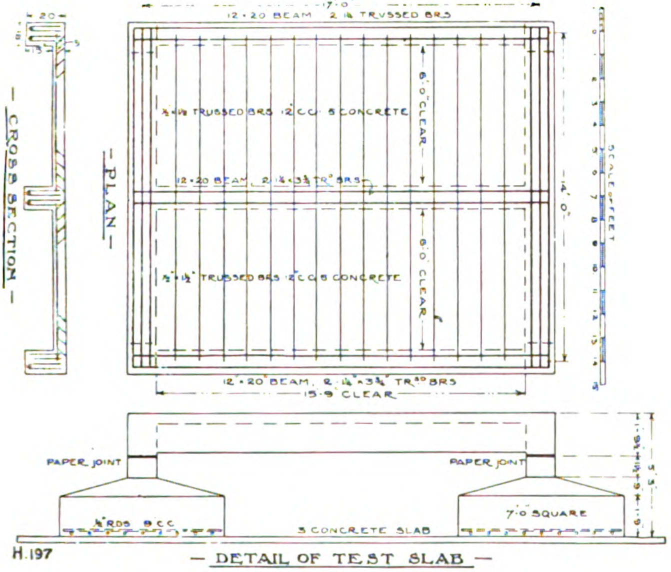


Fig. 19. Bank of England Test.

A reinforced concrete pillar or post square in cross section was tested in June, 1907, by Messrs. William Kirkaldy & Son. *Fig.* 19 shows the arrangement of the reinforcement, which consisted of four trussed bar of the standard section, known as ½ in. by 1½ in. placed vertically in the angles of the post near the outside. The turned-up wings of the bars were placed inwards so as to extend nearly to the centre, thus serving the purpose of binding wires or links to prevent the bars bulging outwards under stress. Small binding wires were used at the two ends to keep the rods in position while the concrete was being rammed. The post measured 12·1 in. on each face, and its length was 120·05 in. The concrete was composed 2 parts ballast, crushed and screened to pass through a ¾-in. mesh sieve, first mixed with 1 part sand passed through a ⅜-in. mesh sieve. Of this combined matrix, four parts were mixed with 1 part of cement. A fairly dry mixture was used, and the post moulded vertically, the concrete being tamped in position with a ½-in. rod used as a rammer.

The post was compressed in Kirkaldy's huge horizontal testing machine. Half the weight of the test piece was taken by suspension at the centre. *Fig.* 21 shows how the post crushed at one end, and *Fig.* 22 shows the post after removal from the machine. The area of the post was 145·1 sq. in. The section of each bar used for reinforcing was 0·38 sq. in., a total of 1·52 sq. in. for the four bars, but deducting the flanges which were turned inwards in the form of wings the area becomes 0·25 sq. in. The four bars, therefore, gave a total section of 1 sq. in., or 0·69 per cent. of the area of the post. The post sustained an ultimate stress of 326,800 lb., equal to 145·9 tons. The depressions in inches at gradually increasing stresses (recorded in lb.) were as follows :—

40,000	60,000	80,000	100,000	120,000	140,000	160,000	180,000	200,000	220,000	240,000	260,000	280,000	300,000
·004	·008	·012	·016	·021	·027	·033	·040	·046	·053	·060	·069	·080	·090

About the same time two columns, 8 ft. long and 10 in. square, each reinforced with four ½-in. Kahn bars, were also tested by Messrs. Kirkaldy for the Hammersmith Public Baths and Washhouses. The concrete was composed of clean, sharp, broken flint gravel of various sizes between ⅛ and ¾ in., mixed with sand and cement in the following proportions: Gravel, 27 cu. ft.; sand, 13½ cu. ft. ; cement, 6½ cwt. This results in a mixture of approximately 4 to 1.

The cement supplied was required generally to conform to the British Standard Specification, with the following alterations to such specifications :—

To have no residue on a sieve of 5,776 meshes per sq. in.

Not more than 5 per cent. on a sieve of 14,400 meshes per sq. in.

Not more than 14 per cent. on a sieve of 32,400 meshes per sq. in. and the test for tensile strength when mixed with sand in the proportion of 3 parts of standard sand to 1 of cement by weight was to be—

At 7 days from gauging, 200 lb. per sq. in.

At 14 days from gauging, 275 lb. per sq. in.

At 28 days from gauging, 350 lb. per sq. in.

The expansion under le Chatelier's apparatus shall not exceed :—

2 millimetres after 24 hours' aeration.

1 millimetre after 7 days' aeration.

Cubes of concrete 6 in. square, made from the materials employed, were crushed by Messrs. Kirkaldy & Sons in May, 1907. Ten specimens were experimented upon, with the following average results :—

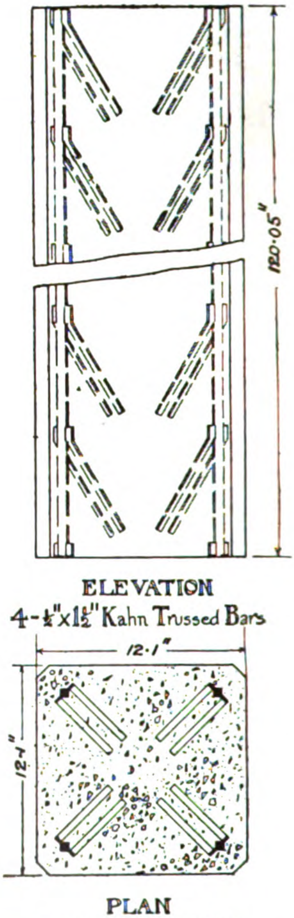
Date when made	Weight, dry, in lbs.	Crushed at tons per sq. ft.
No record	18·32	143·0
November 19th, 1906	18·15	142·7
January 10th, 1907	17·92	104·2

One specimen crushed at 170 tons per sq. ft.

The steel bars were required to bear a tensile stress of not less than 28 or more than 32 tons per sq. in. without breaking, and to elongate at fracture 20 per cent. in a length of 8 in.

The average yield point of the specimens was 22·2 tons per sq. in., and the average maximum stress borne was 32·3 tons.

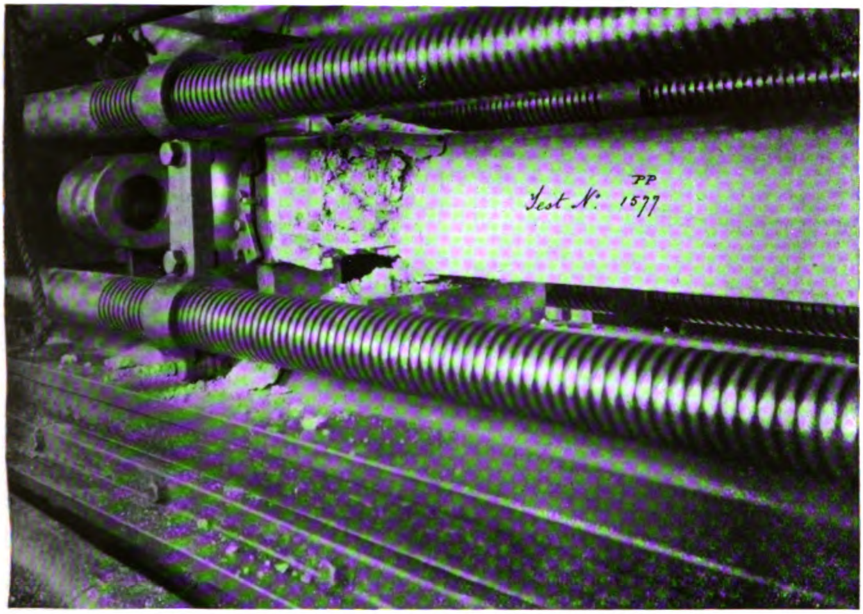
The columns were 8 months old, and crushed at 99 and 107 tons respectively.



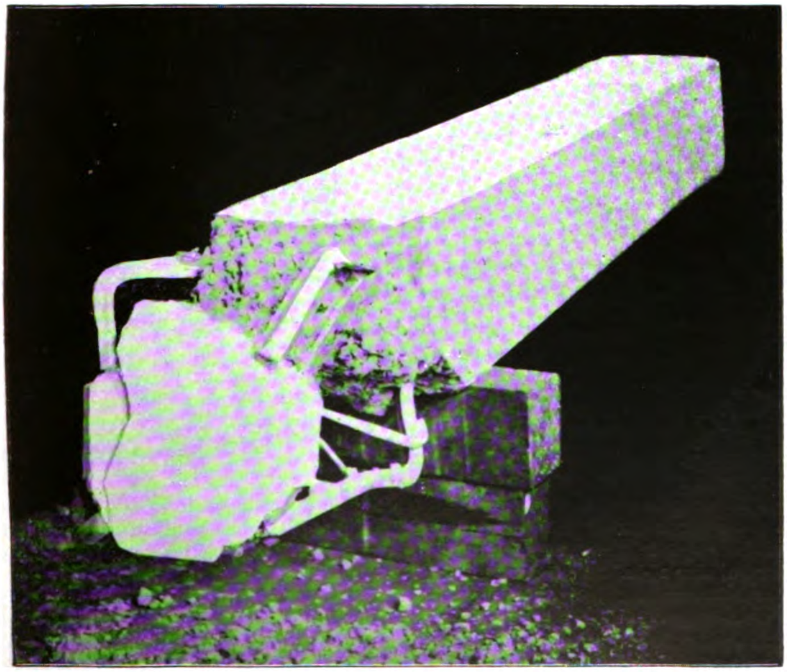
Test with Trussed Bars.
Fig. 20. Diagram of Reinforcemen of Test Post.

The above materials were the same as used for the arched roof trusses at the Baths, which were also tested by Messrs. Kirkaldy, as per details below. (See *Fig.* 20).

The reinforcement of the stanchions below the gallery consisted of six 1¼-in. Kahn bars, above the gallery of nine 1¼-in. Kahn bars, which were carried round the principals with the addition of



Test with Trussed Bars.
Fig. 21. Showing post crushed at one end.



Test with Trussed Bars.
Fig. 22. Post after removal from machine.

TABLE SHEWING LOADS APPLIED TO ROOF & DEFLECTION CAUSED BY SAME

A			B			C			D			E	F			G			H			I			J	K
W	T.W.	D	W	T.W.	D	W	T.W	D	W	T.W	D	D	W	T.W	D	W	T.W	D	W	T.W.	D	W	T.W.	D	D	D
5·13		1	5·31		1	5·508		1	6·65		1	1	6·65		0	5·508		0	6·31		0	5·13		3	0	0 inches
5·00	10·13	1	6·00	10·31	1	8·000	13·508	1	10·00	16·65	1	0	10·00	16·65	0	8·000	13·508	*3	6·00	10·31	1	5·00	10·13	3	0	·008
5·00	15·13	0	5·00	15·31	2	8·000	21·508	1·5	10·00	26·65	1·5	1	10·00	26·65	0	8·000	21·508	0	5·00	15·31	2	5·00	15·13	1	0	·016
5·00	20·13	1	5·00	20·31	1·50	8·000	29·508	2	10·00	36·65	2·0	1	10·00	36·65	*·20	8·000	29·508	1	5·00	20·31	1	5·00	20·13	3	0	·024
1·00	21·13	2	1·00	21·31	1·50	6·000	35·508	2	8·00	44·65	3·0	1	8·00	44·65		6·000	35·508	0	1·00	21·31	2	1·00	21·13	3	0	·028
			6 TONS 2·59 CWTS.													6 TONS 2·59 CWTS										
Extra load applied on this side of Principals only																										
4·00	25·13	1	4·00	25·31	0	4·00	39·50	5	4·00	48·65	2·5	·05			0			1			3			1	0	·032
4·00	29·13	3	4·00	29·31	3	4·00	43·50	1	4·00	52·65	0	0			1			0			1			3	0	·032
4·00	33·13	2	4·00	33·31	1	4·00	47·50	0	4·00	56·65	1	1			1			0			3			2	0	·032
4·00	37·13	3	4·00	37·31	1	4·00	51·50	1	4·00	60·65	1	·05			1			1			2·5			1	0	·032
			9 TONS 6·59 CWTS													6 TONS 2·59 CWTS										
													Extra load applied on this side to equalize load on principals													
													4·00	48·65		4·00	39·508		4·00	25·31		4·00	25·13			·032
													4·00	52·65		4·00	43·508		4·00	29·31		4·00	29·13			·036
													4·00	56·65		4·00	47·508		4·00	33·31		4·00	33·13			·036
													4·00	60·65		4·00	51·508		4·00	37·31		4·00	37·13			·040
			9 TONS 6·59 CWTS													9 TONS 6·59 CWTS										

* Levers reset owing to cradle displacing same

Note — W. — The weight of applied loads in hundred weights, the first weight given being the weight of the cradle
T.W. — Total weight of cradle and applied loads
D — The deflection of the levers in 100th parts of an inch
The movement of the levers may be disregarded as they were more affected by the spring of the staging than the movements in the roof principals
K — The deflections observed by Messrs Kirkaldy & Son by means of a Cathetometer to one tenth millimetre and the calculated equivalent given above in inches

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two 1-in. Kahn bars extending for 18 ft. at the crown of the arch; that to the buttress on the left side of the diagram consisted of two 1¼-in. Kahn bars, and on the right side of four 1-in. Kahn bars, carried over the arches extending across the corridor. There were also two 1¼-in. Kahn bars carried round the secondary trusses supporting the skylight. The average overlapping of the bars was 6 ft., no welding being allowed. In each stanchion, which measured 12 in. by 18 in., there was thus embedded 14 sq. in. of steel reinforcement.

The large purlins were reinforced with two ½-in. bars, and the smaller ones for carrying the fibrous plaster ceiling with one ¾-in. Kahn bar.

DEAD LOAD ON ONE SIDE OF THE PRINCIPALS

WEIGHT OF SLOPING PORTION OF ROOF

DESCRIPTION	LENGTH	WIDTH	WEIGHT PER FOOT SUPER	TOTAL WEIGHT
fir rafters	25′ 6″	19′ 0″	lbs 2·0 ozs	
1″ boarding	·	·	2·8	
felt	·	·	·2	
battens	·	·	1·8	
slates	·	·	2·2	
fibre ceiling	·	·	4·0	
Keenes Cemt fixing	·	·	2·0	
	25′ 6″	19′ 0″	14·4	6904 lbs
Load distributed over 3 points A.B.C also at G.H.I				61·64 cwts
Weight of Sliding Inner Light				
			lbs ozs	lbs ozs
Iron & glass	25′ 6″	9′ 0″	15·0	3442·8
Load distributed at the points C & D also at F & G				30·79 cwts

WEIGHT OF SKYLIGHT & LEAD FLAT

DESCRIPTION	LENGTH	WIDTH	WEIGHT PER FT SUPER OR FT RUN		TOTAL WEIGHT
1″ boarding	25′ 6″	1′ 9″	lbs 2·8 ozs	super	111·12
lead on flat	·	2′ 0″	6·0	do	306·0
lead apron	·		2·8	foot run	63·12
fir ridge	·		6·0	do	127·8
deal frames & sash lights	·	height 4′ 0″	6·0	foot super	612·0
lead to eaves	·		3·12	foot run	95·8
		Number			
Glazing bars	10′ 0″	14	4·8	do do	630·0
Glass	25′ 6″	width 10′ 0″	4·0	super	1020·0
Lead ridge	·		7·8	run	191·4
Keenes Cemt	·		1·0	do	25·8
					3185·4

Load Concentrated at the point D also at · F — 28·42 cwts

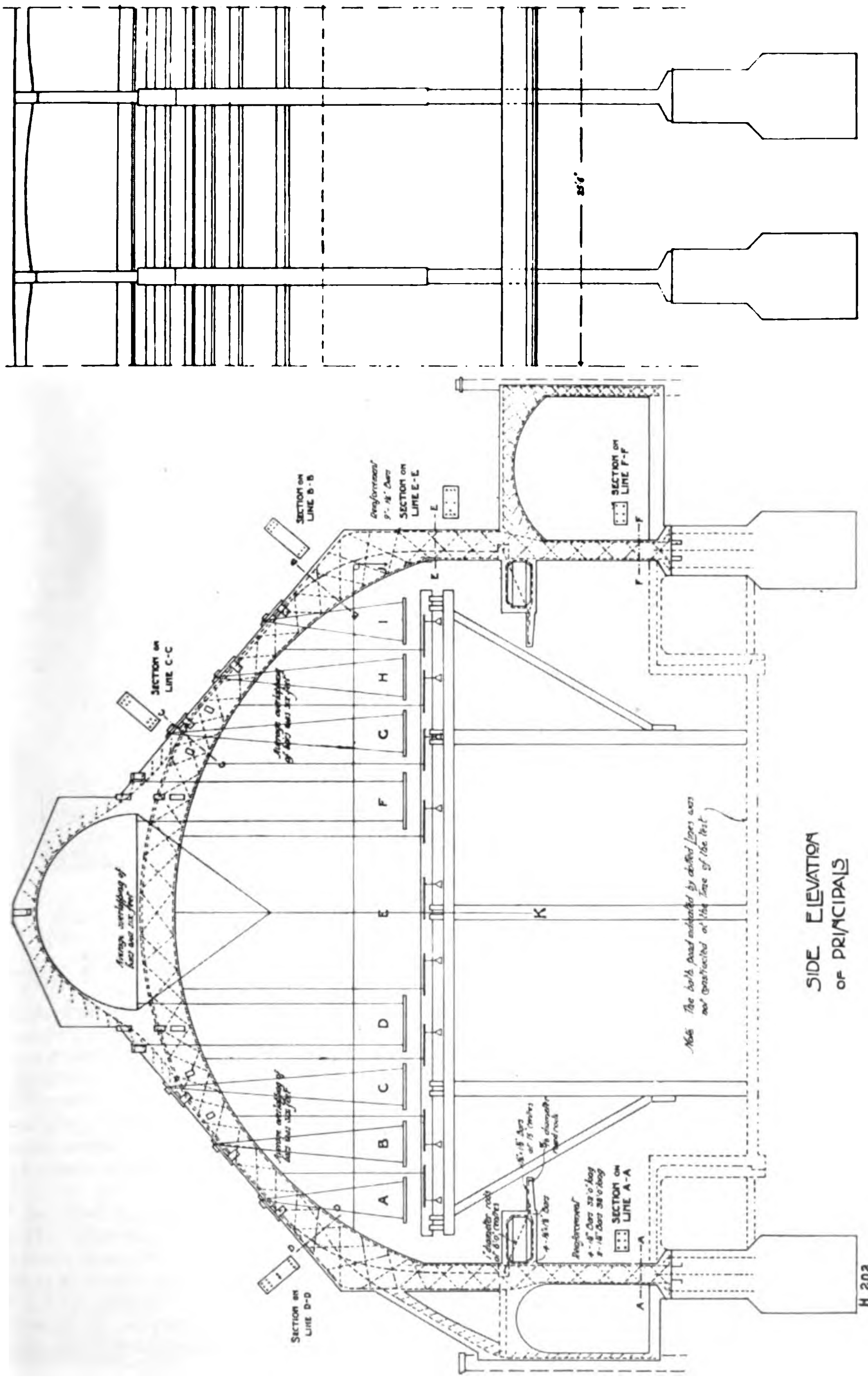
Similar loads applied at					
I	Load at the cradle	A	$\frac{61·64}{3}$	=	20·546 cwts
H	· · ·	B			20·546 ·
G	· · ·	C	$\frac{61·64}{3} + \frac{30·79}{2}$	=	35·941 ·
F	· · ·	D	$28·42 + \frac{30·79}{2}$	=	43·815
					120·848 Cwts

6 Tons 0·848 CWTS.

The side cantilever galleries were constructed with brackets opposite to the principals, having 1-in. diagonal round bars carried across the air space, and reinforced between these brackets with ½-in. Kahn bars spaced 15 in. apart. Two ⅜-in. Kahn bars fixed longitudinally between these brackets were placed next the wall, and also beneath the step formed in the gallery. In addition, round rods ⅝ in. in diameter were placed on the outer edge and all round the gallery; also a 1-in. Kahn bar in the wall at the upper side of the same, and around which the 1-in. diagonal bars were hooked.

The reinforcement in the concrete bases built by the general contractors below the ground floor level consisted of nine 1½-in. diameter round bars.

The Local Government Board, in giving their sanction to a loan for the erection of the public baths and wash-houses, informed the Hammersmith Borough Council that such sanction could not be given for any work in the walls and roof of the first-class bath which involved the use of reinforced concrete, but that the Board would be prepared to consider the matter further if the Borough Council



HAMMERSMITH BATHS TESTS.
Fig. 23. Showing Method of Testing.

would undertake to test one or more ribs after erection in the presence of one of the Board's engineering inspectors, such test to be carried out under the supervision of an independent expert.

The Hammersmith Borough Council wished to take up the loan, and the architect was instructed to make the necessary arrangements to test two of the principals. In conjunction with Mr. David Kirkaldy it was decided that the load should be applied in as near as possible a manner as the ultimate load which was to be borne by the principals, and for this purpose cradles were slung from two of the principals.

The ultimate weight of the roofing materials was ascertained from weighing various specimens, showing the deadload on one side of the principals. The manner of applying the load was by means of bags filled with ballast, each bag weighing 1 cwt. These bags were all checked in weight, and a large number were taken haphazard and checked in weight by Mr. Kirkaldy.

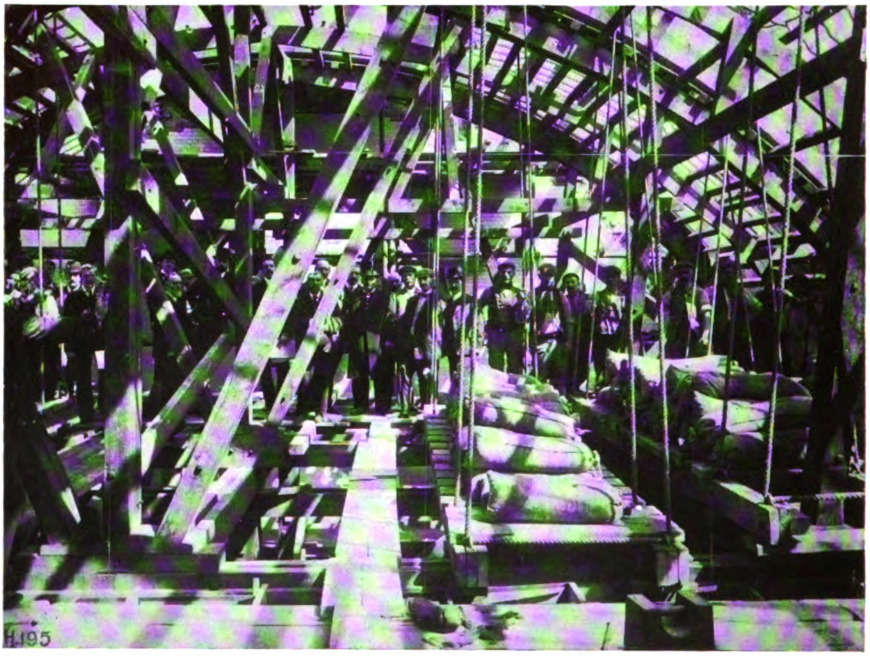


Fig. 24. Test of Reinforced Concrete Roof at Hammersmith Borough Council Swimming Baths.

The deflections were observed by Mr. D. Kirkaldy from the south side of the principals by means of a cathetometer sighting on to a mirror having crossed hairs on its face and suspended by two wires, which were attached to the upper part of the rib and held in position by loose rings. Separate readings were taken by the Local Government engineers and the architect of lever indicators fixed at the various points shown, on to bearers bolted to the staging used for carrying centering employed to erect the ribs, but the movements of these levers must be disregarded as several of the ropes suspending the cradles stretched to such an extent as to displace the lever indicators, and when reset it was noted that the effect of moving the large weight used for testing from the staging on the cradles caused the former to spring.

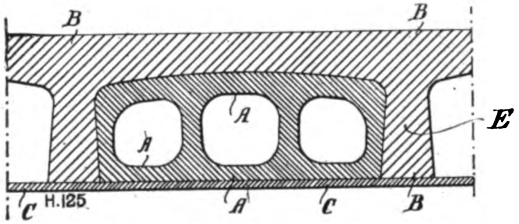
There was no spread at the abutments, as shown by the readings taken by means of a horizontal wire fixed at one end, carried over a pulley, with a weight attached at the other end of the wire. The readings of the pointer show that no movement took place. The roof was superloaded to an extent of 50 per cent. of the permanent dead load. The greatest deflection measured was only $\frac{1}{25}$th part of an inch. And after the removal of the load the roof principals were found on testing to have recovered their original form; in fact, the reading on the cathetometer was above zero, the reason for this being that the cathetometer was set to zero after the cradles were hung, but it showed conclusively that there was no permanent deflection.

(To be continued.)

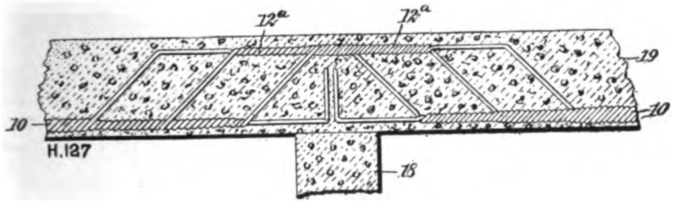
RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. These particulars have been prepared for this journal by Mr. A. W. Farnsworth, of Strand Chambers, Derby.—ED.

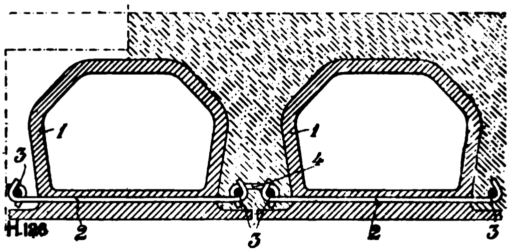
Concrete Floors for Small Residences.—*No. 13885/08. Société E. Ferrand et Pradeau. Accepted November 25/08.*—The use of reinforced concrete floors in smaller residential buildings is considerably restricted by the heavy cost of centering, and a general dislike to the beams projecting below the ceiling. Recent efforts to overcome the difficulty have resulted in the hollow beams, which are brought to the building ready-made and laid close together,' but the inventors state that as lathing is required for the ceilings they do not consider the system satisfactory. They propose to use hollow plaster cores (A), which act as moulds when the concrete is filled in and afterwards remain in position, supported by the undercut sides of the beams (E), and affording a surface (C) for a suitable plaster finish. As the reinforcement is in no way interfered with by this arrangement, it is omitted in the illustration.


H.125

An American Proposal.—*No. 15946. Charles E. Varney. Accepted November 26/08.*—This is another attempt to obtain rigidity in the fixing of the reinforcement during the process of filling in. From the figure it will be readily seen that the inventor's idea consists in intertwining several bars to form the main tension member (10) of the beam. At points where the bending moment decreases some of the twisted bars may be bent upwards to receive the tensile shearing stresses, and in continuous girders, where a negative bending moment occurs at the points of support, the shear members can again be twisted together to form the reinforcement (12). It is claimed that the invention permits accurate distribution of the steel according to the stresses in the beam, and that the shear members are securely held in position, as they form part of the tension members.

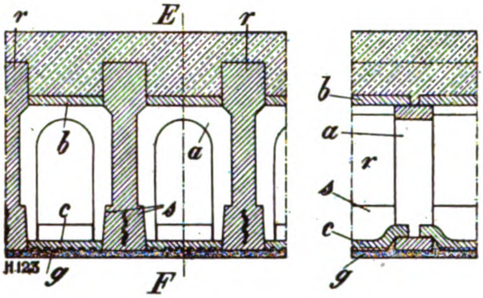

H.127

Rigidity in Construction.—*No. 16773/08. R. Hermanns. Accepted December 3/08.*—When hollow filling blocks are used in reinforced concrete floors in order to provide a suitable surface for ceilings and other reasons, it is pointed out that the position of the reinforcement in the beams may be easily maintained in a thoroughly reliable manner by the simple device described in the specification. During the manufacture of the blocks (1), steel rods (2) are built into them and project on each side far enough to receive the reinforcing bars (3) in the hooked ends. When placed in position, before the concrete is filled in, small

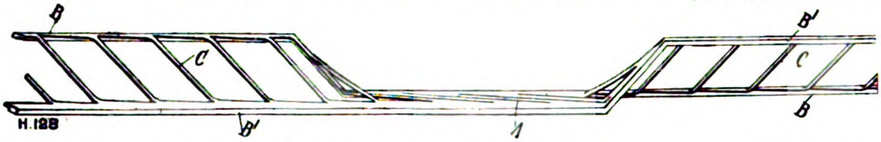

H.126

clamps (4) are placed over the bars at the points of support. It is stated that, provided the reinforcement is sufficiently well supported to avoid sagging, it is very easy, when this method is in use, for the responsible persons to be certain that the bars are not displaced during the filling-in and ramming.

Floors without Centering.—*No. 10215/08. W. Herbst. Accepted December 10/08.*—In the figure is shown another of the many systems of reinforced concrete floors that may be erected without centering. Here the floor is framed with previously prepared beams (r), made with suitable projecting angles (s) to receive and support the remainder of the work. Bridge pieces (a), placed between the joists and resting on the angles (s), carry in turn filling slabs (b and c). The actual floor is laid on the upper slabs (b), and the ceiling plaster (g) is applied to the face of the lower slabs (c). Several modifications of the proposal are described in the specification, but in all cases the leading feature is the construction of floors with joists brought to the job ready made.



Another Reinforcement.—*No. 2118/08. H. Kempton Dyson. Accepted December 17/08.*—The familiar expanded metal principle is applied to this system, which consists in using broad bars of channel section with a thin web and moderately thick flanges. The web is slit into a series of strips (A), which form an open framework when the flanges of the bar (B and B^1) are forced apart. The accompanying figure shows that the inventor proposes to use the portions, B, B^1, as the reinforcement required by bending moment, and the sloping strips (C), formed from the web of the original bar, are intended to take the tensile stresses induced by shear.



Improved Piles.—*No. 26091/08. F. W. Campbell. Accepted January 4/09.*—The inventor has given considerable attention to the possibility of fracture when piles are driven through strata of exceptional hardness. He considers that the risk of damage to the concrete might be reduced if a suitable cushion were interposed between it and the driving point. The cushion is shown in position at C (*Fig.* 1). An alternative method of relieving the pile from severe shocks is shown in *Fig.* 4, where two driving bars (i, i) are placed outside the concrete and serve to transmit the effect of the blows direct to the point. It is stated that the bars can afterwards be withdrawn. The head of the pile is constructed in the usual manner.

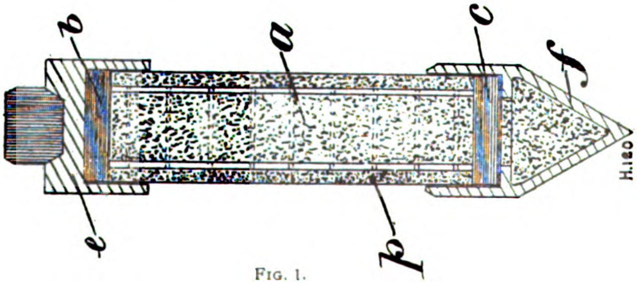
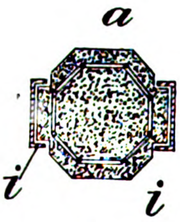
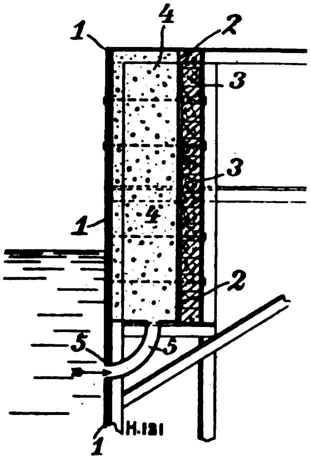


FIG. 1.

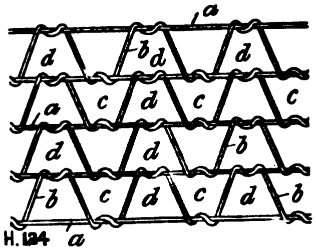


G.

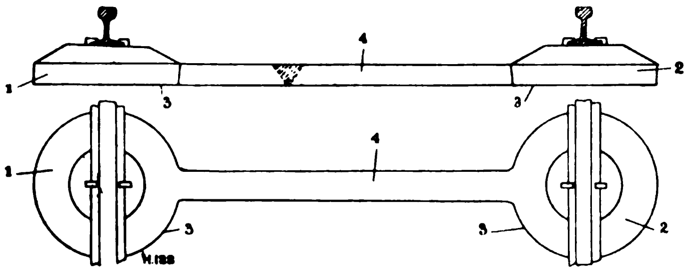


Fortifications in Reinforced Concrete.—*No. 7827/08. N. Shitkewitsch. Accepted February 4/09.* —According to the specification, attempts to produce a successful concrete armouring for ships and fortifications have failed chiefly on account of the brittleness of the materials used, even when reinforced by metallic webs. It is proposed to substitute for the previous aggregates steel turnings and other scrap metal. When used on ships' sides, as illustrated, lighter materials than sand are suggested for filling the voids, and are detailed in the specification. To avoid ramming, which might lead to excessive weight, the cement is forced into the mass through the pipe (5). The timber (3) is simply intended to act as an elastic backing. In ordinary land defences, where weight is of no consideration, the concrete may be rammed in the usual manner. It is claimed that concrete made on this system will offer excellent resistance to modern artillery.

Another Reinforcement.—*No. 13624/08. W. H. Johnson. Accepted February 11/09.*—This is another attempt to provide a satisfactory metallic bond for brickwork, and the material may also be adapted to other purposes. As the majority of wire mesh nettings are corrugated, the inventor points out they are not adapted to resist tensile strains, and he therefore describes in the specification a netting more suitable for the purpose. The wire fabric is made of longitudinal wires (a, a), all straight and parallel to receive tension, interlaced by cross wires (b) twisted round them. It will be noted that the netting can be easily divided by the withdrawal of one of the straight wires.



Concrete Sleepers.—*No. 17443/08. B. de Kovats. Accepted February 18/09.*—After dealing with the defects of reinforced concrete sleepers manufactured in the conventional rectangular form, the following design is submitted as an improvement. The sleeper is formed in two blocks of sufficient area and united by a bar sufficiently stiff to ensure a uniform gauge. The bar is V-shaped in section, so that it will sink into the ballast and not rupture through bending stresses. Several modifications of the design are described, including two separate blocks tied together by a steel bar. Wood wedges (8) are built into the concrete to receive the chair spikes, and the best arrangement of the reinforcement is shown in *Fig.* 4. The inventor claims that the arrangement offers adequate bearing surface without the use of awkward lateral wings, and that the liability to fracture from uneven bedding is also considerably lessened.



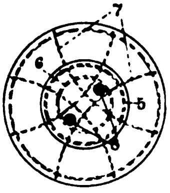
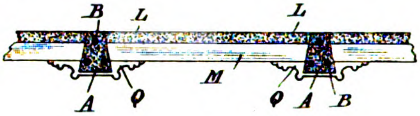


Fig. 4

Another Floor System.—*No. 6662/08. A. Gray. Accepted March 25/09.*—The inventor describes another effort to facilitate the erection of floors and to reduce the cost of centering by the use of ready-made secondary joists and floor slabs placed between or above the main beams. The proposed joists (A) have tapered sides so that the slabs (M), made of any suitable material, can be wedged down between them. If flat ceilings are required the undersides of the slabs can be made flush with the lower faces of the beams; but in the case of panelled ceilings the joists project to receive the decorative cornices as illustrated. The percentage and disposition of the reinforcement vary according to circumstances. The ends of the joists may rest on the lower or upper flanges of the main girder. In the second case the method shown in *Fig.* 2 is suggested, which consists of making each joist with a splayed end E, hooking the reinforcement bars together, and afterwards filling in the V-shaped gap with concrete.



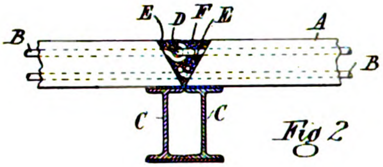


Fig 2

The Reinforcement of Walls.—*No. 7590/08. C. M. Roch and L. G. Mouchel & Partners, Ltd. Accepted April 6/09.*—The object of the invention is to provide reinforcement for walls built of bricks or similar units without the inconvenience of threading the bars through holes in the materials, as suggested in earlier proposals. The result has been attained by making horizontal and vertical grooves in each brick so that the rods or similar reinforcement may be built in and grouted as the work proceeds. The inventors explain that the arrangement need not interfere with the ordinary methods of building, for the bricks can be bonded as usual. They also point out that it results in a considerable increase of strength for the same weight.

FIG. 1.

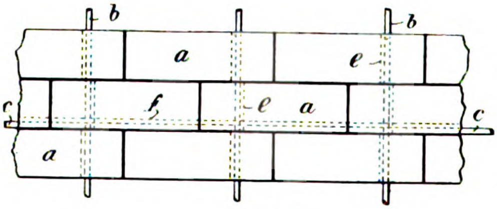
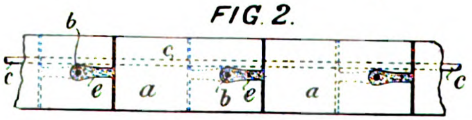


FIG. 2.



A New Bar and its Uses.—*No. 22310/07. E. P. Wells. Amended February 22/09.*—The invention consists in forming a light continuous fin along bars of any section. The fin may be perforated, and is strong enough to withstand the stresses from the shear members or bracing which are attached to it. It is claimed for the reinforcement that the risk of the diagonals slipping on the tension bars is avoided, and there is no necessity to cut into the bars themselves in order to make connections. Several drawings accompany the specification, showing how readily the bar lends itself to the requirements of reinforced concrete construction. Amongst them may be selected *Fig.* 5, a method of introducing distance pieces between the bars, and *Fig.* 14, a typical column section. The advantages of the bars for arches or similar work are also dealt with, and reference made to the fact that the reinforcement can be securely fastened together so that it forms a light braced arch before the concrete is filled in; consequently, the risk of displacement of the steel is reduced.

Fig 5

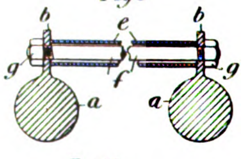
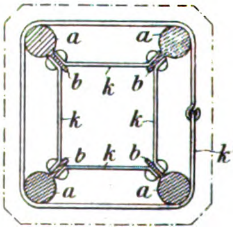


Fig 14



Apparatus for Wall Building.—*No. 5574/08. R. Bowen. Accepted March 11/09.*—No part of reinforced concrete construction as applied to ordinary buildings is more seriously handicapped by the cost of centering than the walls; the device introduced by the inventor has been specially designed to overcome the difficulty. The apparatus consists of a type of travelling mould which is used for sections of the walls in succession, due care being taken to preserve the true alignment. The work is started by the construction of the base or footings in the ordinary manner in order to provide a track for the machine. The actual mould consists of two loose sides (h) with end pieces (2) clamped together by catches (1). It is used in the following manner: Commencing at the end of the wall, the two side plates, which project below the top of the footings, are locked in position with two end plates; the box so formed is then filled with concrete, and as soon as this sets the plates are slacked away and the moulds moved forward for the next filling. The illustration shows the apparatus in this position, and it can be readily seen that only one end plate is required as the first block serves to close the other end of the mould. The two side plates are suitably connected together at each end and travel on runners (v and s) which move along temporary tracks (w and u). The tracks are formed on shallow plates, which assist the alignment of the work, and are moved forward with the mould as required. It is suggested that the apparatus should be made from a light metal such as aluminium, on account of the frequent handling, and it is pointed out that any suitable surface may be given to the wall by the use of plates bearing a corresponding pattern. The inventor claims that concrete walls may be built in this manner at far less cost than when timber shuttering is used.

Fig:1

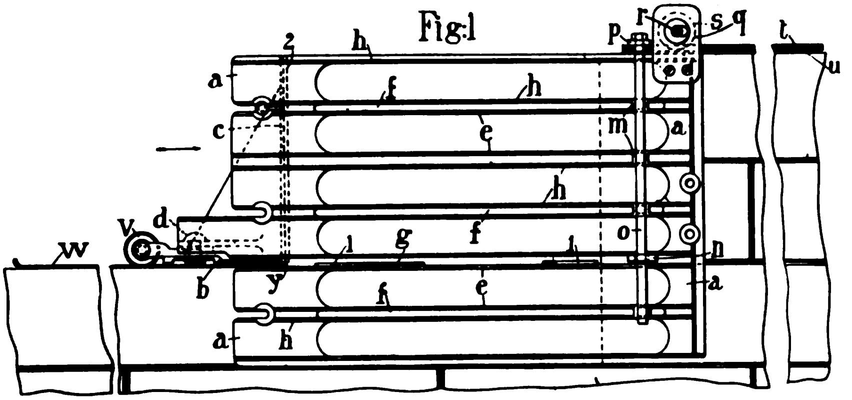
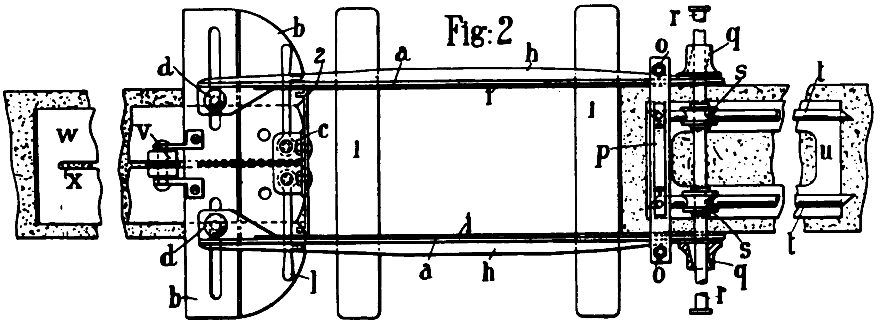


Fig:2



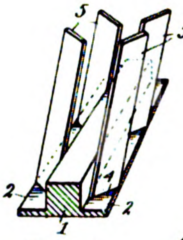


Fig. 5.

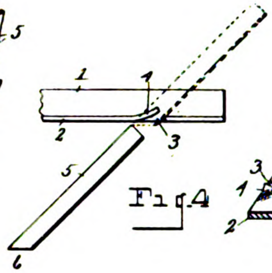


Fig. 4

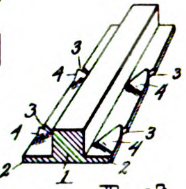
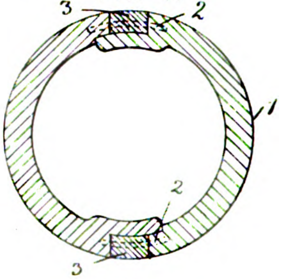


Fig. 3.

An American Bar.—*No. 26786/08. A. Thomas. Accepted April 29/09.*—The bar shown in the illustration is very similar to other known types where the shear members are attached separately. The cross section of the bar is a Tee with a heavy stem (1) intended to resist the tensile stresses, and a light table (2), which is notched at intervals (4) to receive the shear members. The diagonals may be formed from flat bars cut to the required length with their ends bent up under the table of the main bar, as shown at point 3.

FIG. 3.



The Manufacture of Hollow Piles.—*No. 7455/09. W. J. Stewart. Accepted May 20/09.*—The formation of the projections inside the piles referred to in Specification 7454/09 (*see specification below*) adds somewhat to the difficulty of manufacture, but the inventor points out that it may be overcome by making the piles in halves, provided they are suitably joined together. The ordinary reinforcement is omitted from the drawings for the sake of clearness, but short metal rods (2) to form the connection between the two halves of the pile are shown. The groove around them may be filled in with cement (3).

FIG. 4.

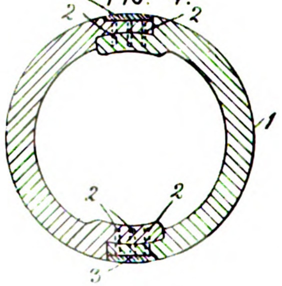
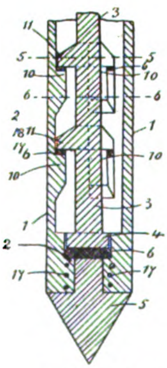


FIG. 1.



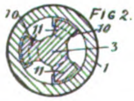


FIG 2.

Methods of Driving Reinforced Concrete Piles.—*No. 7454/09. W. J. Stewart. Accepted May 28/09.*—Several methods of driving hollow piles are suggested by the inventor, of which the one shown in the illustration is typical. It is proposed to form inside the pile a series of shoulders (10), which would receive corresponding projections on the driver (11). Spaces are allowed between the projections large enough to permit the withdrawal of the driver. These are shown in *Fig.* 2, and the driver itself (3) is also drawn in its working position. Suitable cushioning material (6) is introduced between the projections on the two objects.

The Bracing of Piles below the Water. — *No. 5304/09. Armand-Gabriel Considère. Accepted June 10/09.*—The inventor points out that although piles are generally braced together above the water level, when the water is deep they are unsupported for a great part of their length. He has, therefore, devised an arrangement for fixing diagonal bracing of reinforced concrete between them, and below the surface of the water. By reference to the illustration it will be readily seen how this is effected. The diagonal brace (A) is constructed with a swelled end (B), duly reinforced by the rods (C), and provided with a hole large enough to permit it to slide over the pile (D). The socket is retained at its correct height by means of a suspension wire or rope until it is secured by driving home the wedge (F). The bottom of the socket opening is then closed by the packing ring (I), which may be held in position by cords until the opening is filled with hydraulic cement introduced from above through the pipe (K). It is stated that the method described is a satisfactory means of uniting the respective parts of a reinforced concrete structure below the water level.

Fig 1

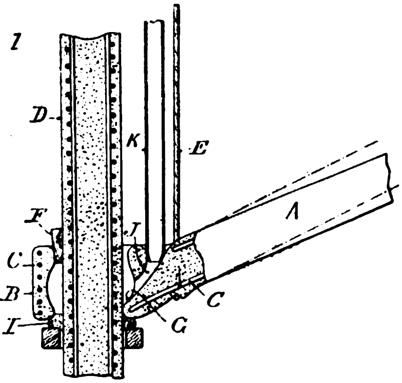
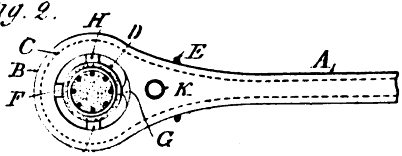
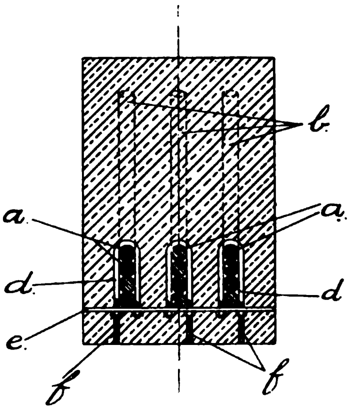
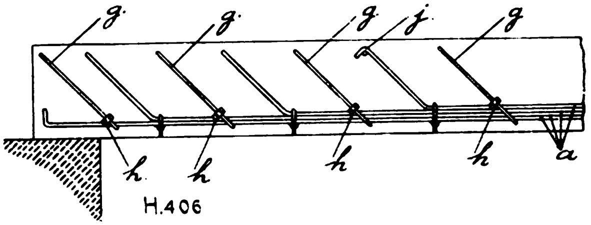


fig. 2.



Improvement in Steel Reinforcement. — *No. 27944/08. Gray & Hurst. Accepted August 12/09.*—The employment of heavy reinforcing rods, say of one inch diameter and upwards, is accompanied by difficulties in bending which entails heating. To overcome the difficulty and to obtain increased rigidity in the steel skeleton, the system described in the specification is suggested. For each large bar is substituted a group of small rods, which may easily be bent cold; they are held together by **U**-shaped clips with screwed ends and nuts. It will be noticed that one end of each clip (*f*) is sufficiently long to rest on the bottom of the mould, in order to maintain the bars at the correct height. Across the screwed ends of the clips are washer plates (*e*), whose length equals the width of the beam; these also fit between the centering, thus preventing lateral displacement. Several modifications of the invention are described in the specification.





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Another Bar.—*No. 19494/08. D. G. Somerville. Accepted September 16/09.*—The efficiency of steel reinforcement when embedded in the concrete is obviously far from being the only point for consideration: low first cost, convenience in transport, and ease in handling claim equal attention. In an attempt to embody all these features in one type of bar, the inventor has designed the one dealt with in the specification. It consists of two or more square rods rolled together and joined by a thin fin between the corners, as shown in the figure. The perforation of the fin at frequent intervals permits the passage of the aggregate and gives a mechanical bond; the diagonal shear members may be passed through the slots in the fin. Where a reversal of stresses is encountered some of the rods themselves may be bent upwards, and it is claimed that they give a larger sectional area of reinforcement than previous systems where the fins are bent upwards.

FIG. 5

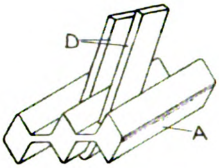


FIG. 6

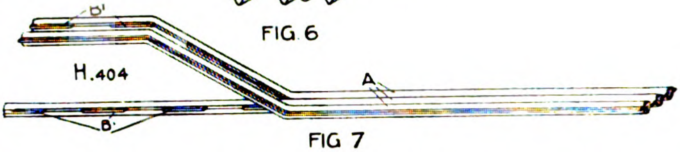
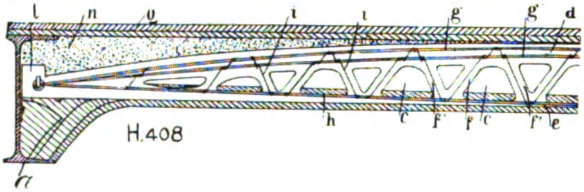


FIG. 7

A Floor Girder. — *No. 2814/09. P. van Leeuw. Accepted September 16/09.*—Here is another attempt to provide an economical ready-made reinforced concrete beam without undue waste of material. The chief feature of the design consists in the adoption of the parabolic compression member (*g*). The reinforcement is of the usual pattern, but it is claimed that the connection of the tension and compression rods at (*j*) is an advantage. The beam is shown in position, and it is stated that the arrangement affords a floor which is fireproof, light, strong, and soundproof.



A Bar with Mechanical Bond.—*No. 6005/09. A. E. Linden. Accepted July 29/09.*—The mechanical bond between the concrete and the reinforcement introduced by the inventor is obtained by forming a series of circumferential ridges on a round rod. In order to support the ridges during rolling they are connected by a projection (1) formed longitudinally along the bar; all exterior edges are rounded, and there are no pockets where air or water may be trapped. In column or wall construction the ridges assist to hold in position any transverse member which may be wired on, or otherwise attached to the verticals.

Fig. 1.

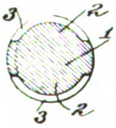
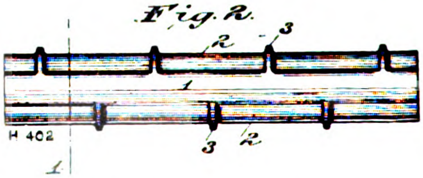


Fig. 2.



A Suggestion for the Construction of Sea Walls.—*No. 20577/08. J. Tromanhauser. Accepted October 28/09.*—In order to overcome some of the difficulties encountered in marine work, the inventor describes in the specification a method of sea wall construction which may be partly carried out in sheltered water. A special timber raft is first constructed on land and launched. The shell of the wall, or part of it, is built up in reinforced concrete on the floating raft forming a pontoon which requires ballasting slightly with sand or gravel; metal hooks (9) fixed to the timber are built into the bases of the walls. During the construction a flooding valve (17) is built in at a convenient level. In *Fig.* 2 the work is shown nearly completed with the shuttering still in position on the upper portion. When the pontoon is finished it is towed into position and sunk by opening the valve. In the event of uneven settlement the water may be pumped out and the structure floated again for readjustment. When finally sunk the interior of the concrete shell may be filled with any suitable material. The claim is for the use of the raft combined with the concrete box and the valve for sinking.

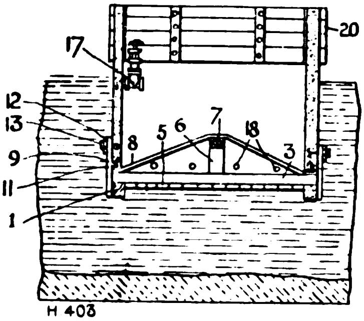


Fig. 2.

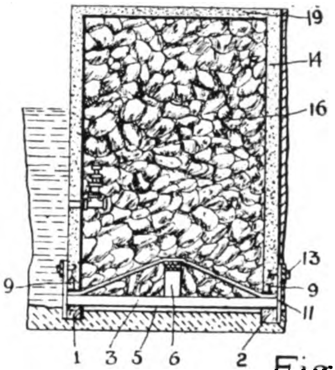
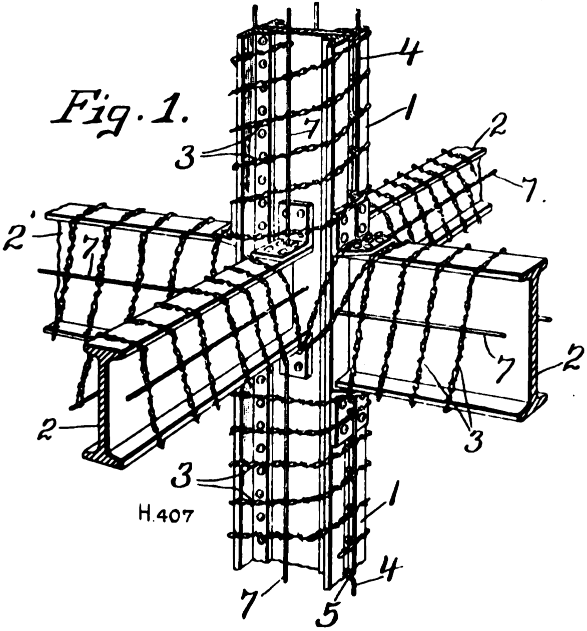
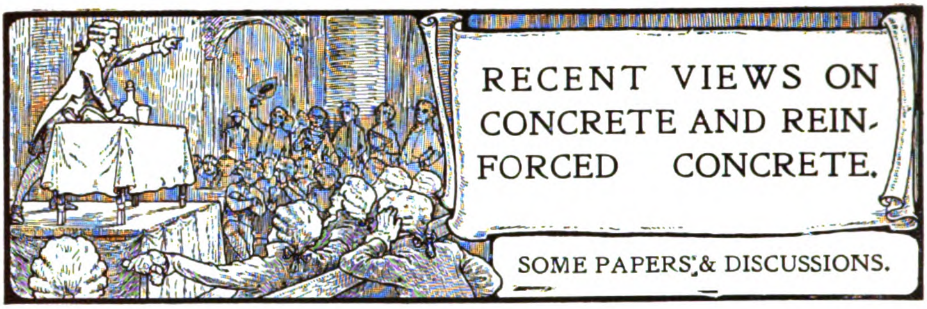


Fig. 4.

The Sheathing of Columns.—*No. 13446/09. T. H. Skinner & Oneida, Ltd. Accepted October 28/09.*—It has now become the recognised practice to cover the stanchions and beams of steel framed buildings with a concrete sheath for fire prevention purposes. It is not, however, an easy matter to provide a satisfactory armature for the concrete by means of netting, or similar material. The inventors' proposal deals chiefly with this difficulty, and by referring to the illustration it will be at once seen that it consists in winding chains spirally round the steel members. Rods (7) are used to assist in maintaining the proper distance between the coils, and provision is made for tightening the chains. It is stated that the system will materially reduce the cost of this class of work, and that the chains can be applied with great speed and accuracy.

Fig. 1.





RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.

We trust that this chapter of our journal may become a recognised reference medium as to the latest views of those who can speak with authority.—ED.

THE ASSOCIATION OF WATER ENGINEERS.

REINFORCED CONCRETE CONSTRUCTION.

By Mr. HARRY W. TAYLOR, Assoc.M.Inst.C.E.

Mr. Harry W. Taylor, Assoc.M.Inst.C.E., of Newcastle-on-Tyne, read a paper on "Reinforced Concrete Construction" before the members of the Association of Water Engineers, at their recent meeting at Liverpool.

Factors of Safety.—The author suggested that before designs were prepared the following particulars should be definitely settled :—(1) The live (or applied or accidental) load per unit; (2) the factor of safety for the live load (usually about 4); (3) the factor of safety for the dead load (usually about 3); (4) the test load (which should be 1½ times the live load).

For the walls and floors of reservoirs, and especially for water towers, the author was of opinion that a higher factor of safety should be used, and in his experience a factor of 5 or even 6 was none too much. Water pressure was the most searching of all pressures, and though theoretically a higher factor is not needed, this was essentially a case where theory and practice differ.

The factor of safety should be based on the elastic limit of the steel. The live or working load should not exceed one-half of the elastic limit, while the test load should not exceed three-quarters of it. Factors of safety were, however, very generally stated in ratio of the breaking weight, and therefore the elastic limit of the steel should be doubled when this ratio was adopted. As an example, with steel whose elastic limit is about one-half of its ultimate strength, the factor of safety would be described as 4, for one-quarter of the breaking load.

Design of Centering.—The primary object in designing centering should be ease in removal and facility for quick re-erection, a point of the utmost importance where there is much repetition on a contract. It should never be forgotten that the cost of centering was nearly always a large percentage of the total cost of the structure, and economy on this item frequently meant an appreciable sum of money. Where it was possible, and the smaller spans permitted, it was frequently desirable to arrange for the floor slab centering to be carried on the secondary beam troughing, and for this troughing to be carried in turn on the column boxing. With large beams of considerable span this, generally speaking, would not be possible, and arrangements must be made for the beam troughing to be carried by struts. The beam troughing should be so designed that the under or bottom board remained in position after the side boards and the floor centering have been removed. All struts under beams, etc., should be wedged from below at the floor level, and not at the top of the struts.

It was also advisable to chamfer the arrises of the columns and beams, as giving a much more pleasing appearance to the work, also to give a camber to the beams of about ½ in. in 10 ft.; if this was not done, the beam, though perfectly straight, would appear to the eye to sag at the centre. The ends of the beams should be haunched on to the supports where this was possible, especially in continuous beams. Thick timber was better than thin, as it lasted much longer, and stood rough handling better, and, generally speaking, was more economical in the end. In the construction of walls it was generally advisable to fix the outer shuttering first, then place the steel in position, and add the inner shuttering and concrete as the work proceeds. To keep the inner and outer faces of the shuttering for walls the proper distance apart perforated wood plugs or concrete separators were used, a bolt through the hole keeping the shuttering tight and rigid. After the shuttering was removed the holes left in the concrete were, of course, filled.

Where a smooth surface to the work was required the face of the timber touching the concrete should be wrought and coated either with mineral oil, boiled soap, or whitewash. These also preserve the life of the timber by preventing the liquid cement soaking into the pores of the wood. If the surface of the work was to be afterwards rendered, boiled soap or whitewash may be preferable to oil; in any case no animal oil of any kind should be used, but only mineral oil such as crude petroleum. After all the centering was fixed and coated with oil or soap, and the steel placed in position, it was advisable to thoroughly flush the centering and moulds with water before any concreting is commenced.

Steelwork.—It would save considerable time if the steel were delivered cut to the required lengths, as by this means a good deal of smith's work on the job would be avoided. A convenient way of bending the smaller bars was to use a long temporary bench, constructed of thick timber with strong pins or plugs in same to bend the bars upon. These pins should be arranged to form a template, and thus the work would be accurate and expeditious. Smooth bars, whether round, square, or hexagonal, must be anchored at the ends, either by bending at right angles or by splitting open like a fish-tail or by means of a washer and nut, the latter being probably the most effective method. Steel bars in floors and walls must be crossed and bars in the beams must be cranked over the supports irrespective of the system used. Where openings occur, either in floors or in walls, it was always advisable to put additional steel round the openings. It was always preferable to have the inside of the steelwork of a column as clear and free from projections as possible so that the ramming of the concrete might be thorough. Arrangements must be made for keeping the steel in the column boxes in its correct position while the concrete was being deposited in them; this could usually be done by temporary wedges. The steel bars in the beams could either be suspended from above or by the stirrups or shear hangers, or they can be carried on temporary wooden slips or by concrete bolsters in the bottom of the troughing.

The bars in floor slabs could be kept the required distance above the centering by means of notched wooden templates, or by a round iron rod; these were pulled along the floor just in front of the concrete as it was being deposited. Another method was by means of small concrete blocks which were embedded in the concrete and became part of the structure. It was in every way desirable that all or nearly all bars where they cross each other should be wired together with soft iron wire, thus guarding against displacement when the concrete was being rammed around them.

Concrete.—Good concrete should be dense, that is to say, containing as few voids as possible; in this respect the selection of the gravel and sand was a matter deserving great care and attention. Hitherto it had been the custom to specify that concrete should be composed of so many parts by measure of gravel, so many parts of sand to one part of cement, regardless of the voids in the two materials. This, in the author's opinion, was a mistake, and the proportion of voids in the gravel and sand should be ascertained, so as to obtain as dense and homogeneous a mass as possible.

Specifications very frequently call for coarse, sharp, clean, gritty sand, but the author believed a sand containing a proportion of fine particles was preferable in the majority of cases. Of course, a dense concrete was not always needed, such, for instance, as internal floors, but where work was required to be weather-tight, and especially water-tight, sand containing a considerable proportion of fine particles was in every way preferable. In depositing concrete in the moulds and centering the chief object was for it to be homogeneous; if it was dropped from a height (even of 6 or 7 ft.) the larger stones tended to separate from the mass and honeycombed work would result. Concrete should not be dropped more than a couple of feet; if it must descend from a greater height than this, it was better to slide it down a pipe or shoot. In ramming concrete, light rammers were preferable to heavy rammers which were apt to displace the steelwork. Concrete on small works was invariably mixed by hand, while on large contracts a mixer was generally used. If a concrete mixer was used the best work would undoubtedly be obtained with a batch mixer as distinct from a continuous mixer. If a continuous mixer is used it frequently happens that the stone comes through first, and the cement and sand last, and consequently the result was most unsatisfactory.

The author's experience was that wet concrete was preferable to plastic concrete, because it filled the moulds and spaces better and flowed between and around the steel bars more freely.

It was frequently the duty of a water engineer to design and construct reservoirs, tanks, and water towers, and it was obviously of the greatest importance that the work when finished should be watertight. This point was so excellently described in the *Engineering Record* that the author made no apology for quoting the following extract from this paper: "The great obstacle hitherto experienced in making waterproof concrete has been its highly porous character. With the dry mixtures used in times past the porosity of the concrete was excessive, and not the least of the many advantages accruing to the use of wet mixtures is the greater solidity and density conferred upon the mass. A wet mixture not only causes all portions of the mass to run together in greater solidity, but it enables the finer materials of the aggregate to flow freely and thoroughly into the spaces between the coarser particles, thus producing a much more continuous and dense interior mass. This obviously means a greatly reduced permeability to water and a much enhanced capacity to resist seepage through it. However much care may be taken in securing a thorough and intimate mixture of the component parts, some seepage will generally result under pressures of 40 to 60 pounds or less per square inch."

Whatever materials were used for rendering concrete waterproof they must be such as would not affect the strength and durability of the concrete. It had been clearly established by tests that the presence of a small percentage of fine clay did not necessarily injure the strength of the concrete, while it certainly assisted very materially in securing a much more waterproof concrete. This was, of course, altogether contrary to the former opinions of engineers. The use of soap and alum was fairly well known, both applied either as alternate washes on the concrete or as a solution in mixing the mortar for cement rendering. The addition of a soap and alum solution to cement rendering is undoubtedly beneficial where a watertight surface was required, but it must be remembered that if the sand itself was coarse and sharp the resulting work would probably not be watertight, there being an insufficient percentage of small particles to thoroughly fill all the voids. A material which was largely used on the Continent for this purpose was powdered pumice stone or "trass."

Maturing of Concrete.—It was often advisable to make test cubes from the same concrete that was being used on the works so as to note the process of hardening. It was important that the moulds in which these test cubes were made should be thoroughly wet when the concrete was placed in them, or the dry wood would suck the moisture out of the concrete, and consequently the test would be of no real value. The author, however, preferred to place reliance upon the actual concrete work itself, and considers it better practice to test important beams with a chisel to ascertain their hardness; if this was done near the neutral axis it would not affect the strength of the beam.

Removal of Centering. -- Generally speaking, it would be safe to remove the centering from under floor slabs in from 7 to 14 days after the concrete had been deposited. The side boards of the beams and the boxing of columns might also be removed in about the same time. The bottom boards under beams of spans, say, up to 20 or 25 ft., should not be removed for at least four weeks, while for longer beams an extra length of time for hardening should be allowed. A rule should be made on all contracts never to touch the struts under the bottom boards of the beams until the concrete had set hard or damage by shear was almost certain to result.

Frost and Heat. — It occasionally happened that work had to be finished within a given period irrespective of weather conditions, and if such work should be driven into the winter risk of frosts would be incurred. Where it was feasible and time permits, the author thinks it better to stop work altogether, and protect that portion already done in the best manner possible. This could generally be accomplished by covering the concrete with hay or straw about 12 in. thick, with boards or matting on the top. Where, however, the work must be finished regardless of frost special precautions must be taken. Probably the simplest way was to heat the gravel and sand to about 70° or 80° (Fahr.), and use warm water of about 100° temperature in mixing the concrete. Immediately the concrete had been placed in position it must be protected by canvas tents connected with salamanders or fires by hot air pipes. The pipes should be placed near the concrete so that the hot air from the fire can pass inside the tent formed by the canvas, and so raise the temperature sufficiently to protect the concrete from frost. During hot, dry weather, and especially where the sun played directly upon it, the concrete would dry very rapidly, and provision must be made in such cases both for screening the concrete from the sun and also for keeping it moist. The surface of newly-laid concrete should be kept in a moist state for not less than six or seven days during hot weather.

Conclusion.—It was frequently contended that reinforced concrete was in its infancy, and that sufficient time had not yet elapsed to form a reliable opinion as to its lasting qualities. The fact that such a large number of structures had been built, especially during the last 15 years, and had answered their purpose perfectly, was, in the author's opinion, reliable evidence as to the strength and durability of these structures. It should always be remembered that if a reinforced concrete structure was inherently weak it would fail the first time it was loaded. As the concrete continues to harden for 10 or 15 years its strength increases also, and the author had yet to learn of a case where a reinforced concrete structure having been erected, say, for five years, had afterwards collapsed.

AMERICAN SOCIETY FOR TESTING MATERIALS.

NOTES ON THE BEARING VALUE OF RODS EMBEDDED IN CONCRETE.

Paper by ROBERT A. CUMMINGS, M.Am.Soc.C.E.

Shear.—If a load is so placed that a reinforced concrete member is subjected to vertical shear, we reason that the concrete and the metal reinforcement act together. Our structures are frequently designed in accordance with this assumption.

Three or four years ago, during a convention of this Society, the writer brought to the attention of a party of engineers the fallacy of assuming that two such materials act together in shear. Since that time the subject has not been publicly discussed. Perhaps this may be accounted for by the fact that in the large number of published tests on reinforced concrete beams failure by vertical shear has been the exception; and wherever beams have thus failed, the failure has been attributed to insufficient sectional area of concrete.

The common practice in determining the end shear of beams is to allow so much for the concrete and to make up any deficiency with steel at so many thousand pounds per sq. in. of cross-sectional area. The basis for such practice cannot be explained satisfactorily.

While it is quite proper to consider the area of concrete as available for shearing, the steel should not be included. It would be more appropriate to regard the relation of the concrete to the steel as bearing on the rods, if they are sufficiently anchored and suitably placed.

Bearing Value of Bolts.—Analogous to the above combination of concrete and rods is that of bolts embedded in concrete for attaching brackets to support a load. Neglecting friction, the load will ultimately reach the concrete through the bearing of the embedded bolts. What, then, will be the bearing value of bolts embedded in concrete in resisting a force acting at right angles to the axis of the bolt? This will naturally depend on two things, the size and rigidity of the bolt and the density of the concrete.

This question recently arose in the writer's practice in connection with methods for supporting the centering for concrete arches, also for supporting steel brackets on concrete columns by means of embedded bolts projecting from the concrete. These bolts were in single shear and in proper proportion. The bearing value of the concrete to receive the load from the bolts was unknown.

The object of the following tests, which were conducted by E. D. McCready, of the Lehigh Valley

Testing Laboratory, Allentown, Pa., under the direction of the writer, was to obtain the bearing value for such bolts.

Tests were made on ¾-in. square and ¾-in. round straight steel rods embedded in a short column of concrete with the ends of the rods projecting equally about 3 in. on either side. When the specimen was placed in the testing machine, the projecting rods were evenly supported on cast-iron bearings which were held in close contact with the concrete. The rods were thus bearing and in double shear. Specimens were made to be tested at 30, 60, and 90 days. In all 24 specimens were made—two each for each kind of rod and for each period being made from both 1 : 2 : 4 and 1 : 3 : 6 mixtures. It was not convenient to test the first lot at 30 days, and they were tested at 35 days. These are the tests described in this paper.

Materials.—The concrete for these tests was made from bank sand and gravel screened from the sand. The sand was fairly clean and well graded, and of the following composition :—

	Per cent.		Per cent
Passing the 200-mesh sieve ...	2·0	Passing the 30-mesh sieve ...	22·2
„ „ 100 „ „ ...	3·2	„ „ 20 „ „ ...	43·6
„ „ 80 „ „ ...	4·0	„ „ 10 „ „ ...	77·4
„ „ 50 „ „ ...	8·4	„ „ 4 „ „ ...	100·0
„ „ 40 „ „ ...	13·6		

The percentage of voids determined by shaking down in water was 32·3 per cent. The composition of the gravel was as follows :—

	Per cent.		Per cent.
Passing the ¼-in. mesh	2·1	Passing the 1-in. mesh ...	91·8
„ „ ½ „	30·2	„ „ 2 „ ...	100·0
„ „ ¾ „	56·5		

A standard brand of Portland cement was used : tensile strength, neat 24 hrs. ; 472 lbs. ; seven days, 903 lbs. ; 28 days, 832 lbs. ; with standard quartz, 3 : 1 seven days, 234 ; 28 days, 299. Setting time, 3 hrs. 20 min., initial ; 7 hrs. 15 min., final. Fineness, 200 sieve, 77·6 per cent. ; 100 sieve, 93·2 per cent.

Compression cylinders 8 in. diameter and 16 in. high were made up in the proportion 1 : 2 : 4 and 1 : 3 : 6, three for each test at each period. Those tested at 30 days broke as follows :—

1 : 2 : 4	1 : 3 : 6
1,932	603
1,721	721
2,127 lbs.	909
1,927 per sq. in.	744 lb. per sq. in.

Method of Testing.—Bearing test specimens were square columns with a 10-in. by 10-in. base and 24 in. high. As originally made, each column had a 6-in. footing on one side to give stability to the block in testing, because it was first planned to apply pressure at one point only. The specimens were made in wooden form which had a ¾-in. square hole cut through two opposite sides (one of the sides being that on which the footing projected, and which we will call the "front"), and exactly the same distance from the bottom—just midway between the upper surface of the footing and the top of the column. The rod to be embedded was put through these holes and projected equally from front and back (about 3 in.). This latter fact permitted a change in the original plan, and the specimen, were tested in double shear.

For this purpose two iron castings were made, ⅞ in. in thickness, and in vertical section like an inverted letter T, the base of which was 5 in. and the height 12 in. These castings were 14 in. long, and served as supports for the test specimens, the projecting rods bearing on either support. The supports were held close to the concrete by iron bolts extending through both castings, about 1½ in. from either edge and 2 in. from the top. The bolts were threaded on each end so that the supporting plates could be drawn to contact with the concrete.

Pressure was applied through a 1½-in. round bar on top of the specimen, at right angles to the direction of the embedded bar. The load was applied in increments of 1,000 lbs. each, careful measurements being taken and observations made after each loading to determine the deflection of the bar, and note the condition of the concrete. Measurements were made with an inside micrometer and checked with an inside caliper and outside micrometer. Electrical contact was used.

Contact points were marked on the upper surface of the projecting bar, right against the surface of the concrete and on the upper side of a specially designed iron frame attached to the concrete column by four pointed set screws. This frame was attached at a height of about an inch above the projecting rod, in order to avoid, as far as possible, all error due to crushing or compression of the concrete. An extension above the frame was provided for the upper point of contact, which was 4 to 5 in. above the rod.

Description of the Tests.—Failure in each case was caused by the bending of the rod for about an inch in from the surface of the concrete, causing the latter to powder and crumble, and finally scale off to a depth of ¼ in. to ½ in. The surface area thus scaled off varied from 1¼ in. to 3 in. in diameter, according to the nature of the aggregate at the surface at that point. When the rod began to bend and the scaling off of the concrete was noticed, the test was practically at an end as the rod simply continued to bend, and it was not possible to increase the loading. In those cases where several thousand pounds were added to the load after the breaking out of the concrete before complete failure occurred, the rod was supported by one or more large pebbles which had not broken out.

This series of tests suggests that the subject of the bearing value of rods embedded in concrete should be more fully investigated with reference to the effect of the size, shape, and rigidity of the rod as well as the character of the concrete. No final conclusions can be drawn from a single series of tests. In fact the whole subject of reinforced concrete is an undeveloped and fascinating field, and we are wofully in the dark as to internal stresses and the influence of variations in the position and amount of embedded reinforcement, witness the extraordinary variety of systems of reinforcement and the disagreement of authorities except as to simple stresses.

Table Showing Deflections.

Total Pressure, lbs.	¾ in. Square Rods				¾ in. Round Rods			
	No. 1, Front	No. 1, Back	No. 2, Front	No. 2, Back	No. 1, Front	No. 1, Back	No. 2, Front	No. 2, Back
			Concrete 1 : 2 : 4					
1,000	·002	·001	·000	·000	·001	·000	·000	·000
2,000	·003	·001	·002	·001	·005	·000	·002	·001
3,000	·005	·003	·005	·004	·007	·005	·005	·004
4,000	·006	·005	·010	·007	·008	·007	·007	·007
5,000	·008	·010	·014	·009	·010	·009	·008	·009
6,000	·009	·012	·017	·011	·012	·011	·010	·010
7,000	·013	·018	·022	·016	·019	·016	·013	·015
8,000	·018	·025	·028	·020	·027	·021	·016	·017
9,000	·021	·033	·035	·025	·035*	·026*	·020	·021
10,000	·028	·040	·043*	·031	·045	·033	·025	·025
11,000	·034	·046	·060	·040	·066	·042	·038*	·027
12,000	·044	·051	·072	·048	·084	·060	·045	·030*
13,000	·051	·055	·094	·061*	·101	·077	·061†	·038†
14,000	·066	·060	·110	·080	·126	·091	·095	·080
15,000	·073	·080	·157	·112	·132†	·110†	—	—
16,000	·081	·093	·205†	·160	·145	·127	—	—
17,000	·104	·111	·260	·220†	—	—	—	—
18,000	·135	·127	—	—	—	—	—	—
19,000	·198	·220	—	—	—	—	—	—
20,000	—	—	—	—	—	—	—	—
			Concrete 1 : 3 : 6					
1,000	·000	·000	·002	·000	·000	·000	·000	·003
2,000	·005	·003	·002	·000	·005	·001	·005	·006
3,000	·010	·005	·004	·003	·007	·003	·006	·009
4,000	·015	·007	·007	·005	·009	·006	·007	·011
5,000	·020	·010	·008	·006	·015	·010	·012	·014
6,000	·024	·015	·010	·008	·018	·012	·014	·016
7,000	·030	·017	·016	·011	·022	·014	·018	·020
8,000	·036	·021	·021	·016	·029	·020	·023	·023
9,000	·041	·026	·029*	·024*	·033	·029	·028	·039*
10,000	·056	·030	·038	·033	·040	·032	·041*	·060
11,000	·059	·031	·051	·040	·058*	·041	·055	·077
12,000	·068	·033	·095†	·082†	·070	·066*	·080†	·092
13,000	·075	·037*	·156	·125	·095†	·084	·027	·130†
14,000	·084	·041	·169	·147	·120	·111†	—	—
15,000	·094†	·045	·195	·160	—	—	—	—
16,000	·120	·069	—	—	—	—	—	—
17,000	·158	·081†	—	—	—	—	—	—
18,000	·201	·115	—	—	—	—	—	—
19,000	·298	·205	—	—	—	—	—	—
20,000	—	—	—	—	—	—	—	—

* Cement commenced to powder under the rod.

† Cement commenced to crumble under the rod.

AMERICAN SOCIETY FOR TESTING MATERIALS.

TESTS OF CONCRETE COLUMNS.

Paper by Mr. O. WITHEY.

This was the title of a valuable paper by Mr. O. Withey. In his absence it was read by Professor Turneaure before the above Society.

The paper consisted of a report on tests of plain and reinforced concrete columns made in the laboratory for testing materials in the University of Wisconsin during the past year. Preliminary tests were first made upon twenty columns. The various experiments included plain columns, columns reinforced with latticed angle structural steel, columns reinforced with high carbon steel spirals, columns reinforced with spirals and vertical steel rods and columns reinforced with vertical steel rods and ties a foot apart. A more extended series of tests was made then on thirty-two columns containing spiral reinforcement, the variables being percentage of vertical steel and percentage of spiral steel and richness of mix.

The general character of the results was shown on diagrams which were explained in detail by Professor Turneaure. The paper comprised only a brief discussion of the main features of the test, as a more complete account of the preliminary series will be found in the bulletin of the University of Wisconsin, now in the press. From the results of the tests the following conclusions were presented by the author:—

1. A small amount, ½ to 1 per cent., of closely-spaced lateral reinforcement, such as the spirals used, will greatly increase the toughness and ultimate strength of a concrete beam, but does not materially affect the yield point. More than 1 per cent. of lateral reinforcement does not appear to be necessary.

2. Vertical steel in combination with such a lateral reinforcement raises the yield point and ultimate strength of the column and increases its stiffness. Columns reinforced with vertical steel only are brittle and fail suddenly when the yield point of the steel is reached, but are considerably stronger than plain columns made from the same grade of concrete.

3. Increasing the amount of cement in a spirally reinforced column increases the strength and stiffness of the column. A column made of rich concrete or mortar, and containing small percentages of longitudinal and lateral reinforcement, is without doubt fully as stiff and strong and more economical than one made from a leaner mix reinforced with considerably more steel. In these tests, doubling the amount of cement increased the yield point and ultimate strength of the columns without vertical steel, about 100 per cent. and added about 50 per cent. to the strength of those with 6 1/10 per cent. vertical steel.

4. From the behaviour of the columns reinforced with spirals and vertical steel, under test and the results computed, it would seem that a static load, equal to 35 to 40 per cent. of the yield point, would be a safe working load.

5. The results obtained from tests of columns reinforced with structural steel indicate that such columns have considerable strength and toughness, and that the steel and concrete act in unison up to the yield point of the former. The shell of the concrete will remain intact until the yield point of the steel is reached, but no allowance should be made for its strength and stiffness.

6. As many of the blotters on the tops and bottoms of the columns bore imprints of the vertical steel after failure, it would seem a safe precaution to use bed plates at the foundations for such columns and thus prevent any possibility of the steel punching through the concrete under an excessive load.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE BRIDGES AT CHINGFORD.

A NUMBER of reinforced concrete bridges are being erected in connection with the work of the Metropolitan Water Board's new reservoir at Chingford for facilitating the water supply there.

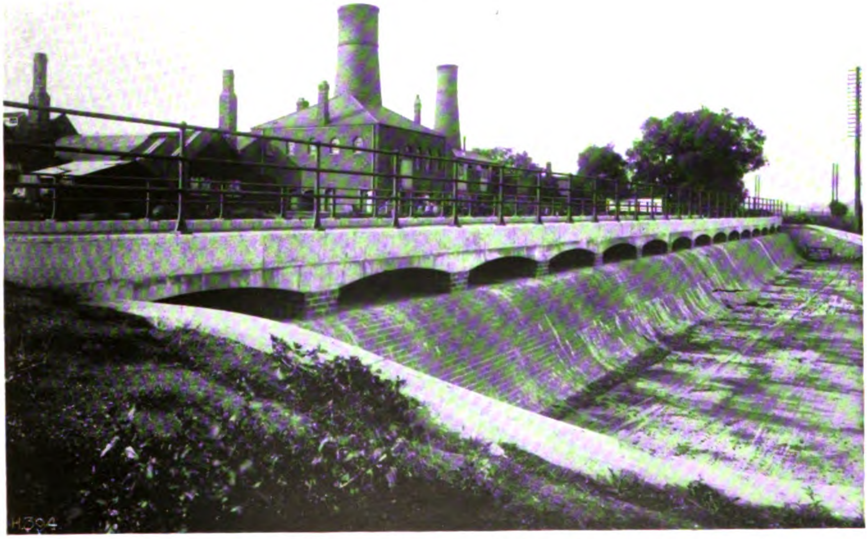
The work at Chingford comprises a large reservoir in the Lea valley, south of Enfield Lock, which will have a capacity of three million gallons, with a water area of 416 acres, and will necessitate the construction of over four miles of embankment.

An overflow channel from the Lea navigation has been constructed to conduct the surplus water past the reservoir embankment. At this point the towing path is carried across the overflow on a reinforced concrete bridge, of which we give an illustration.

Another bridge of similar material carrying the main Ponders End Chingford Road, which has been widened for about a mile, is also completed. This bridge is formed of three spans each 27 ft. 6 in. wide, with a rise of 5 ft.

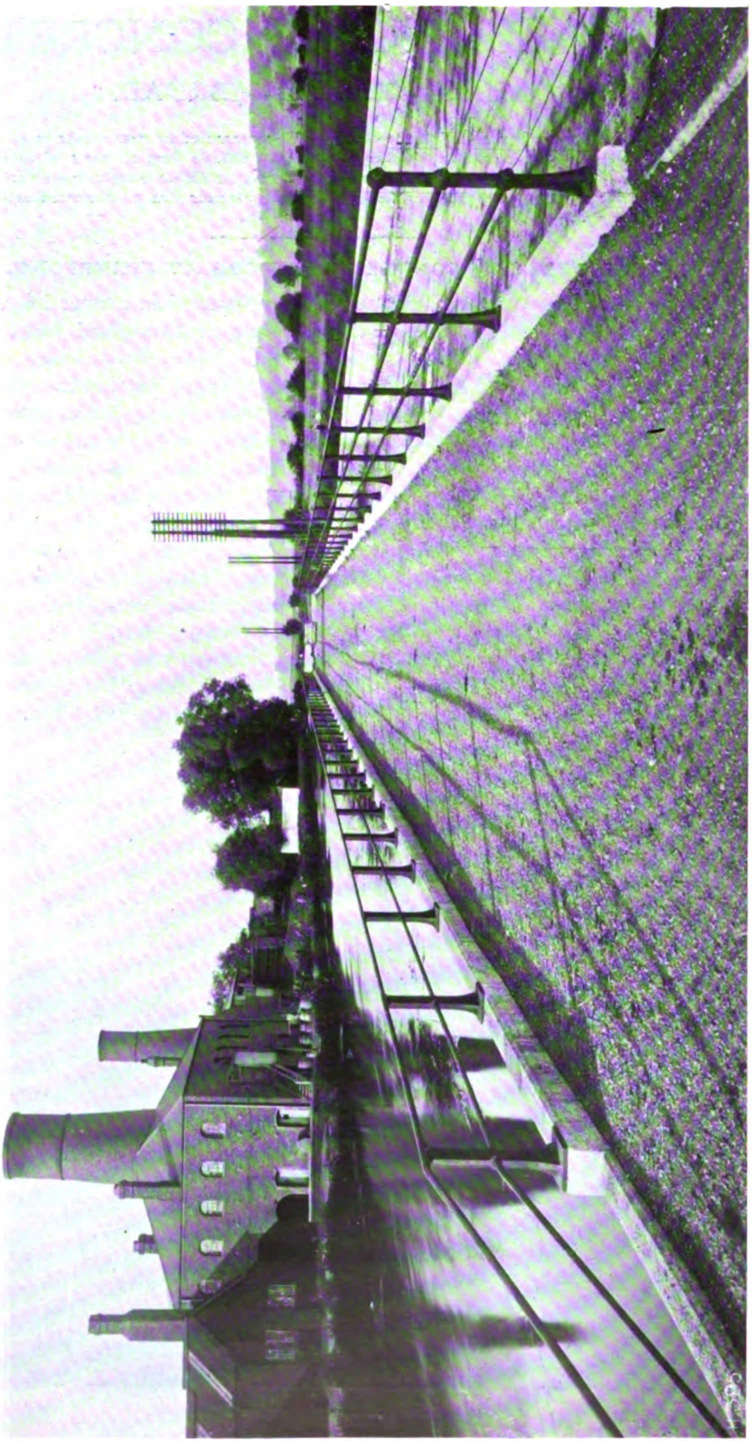
Two reinforced concrete arch bridges of 55 ft. span and 5 ft. 6 in. rise have also been built across the River Lea diversion, and on page 63 we show a view of the arches for one of these. In addition to the above there are two smaller bridges with water towers.

All the reinforced concrete work in connection with these bridges, of which there are



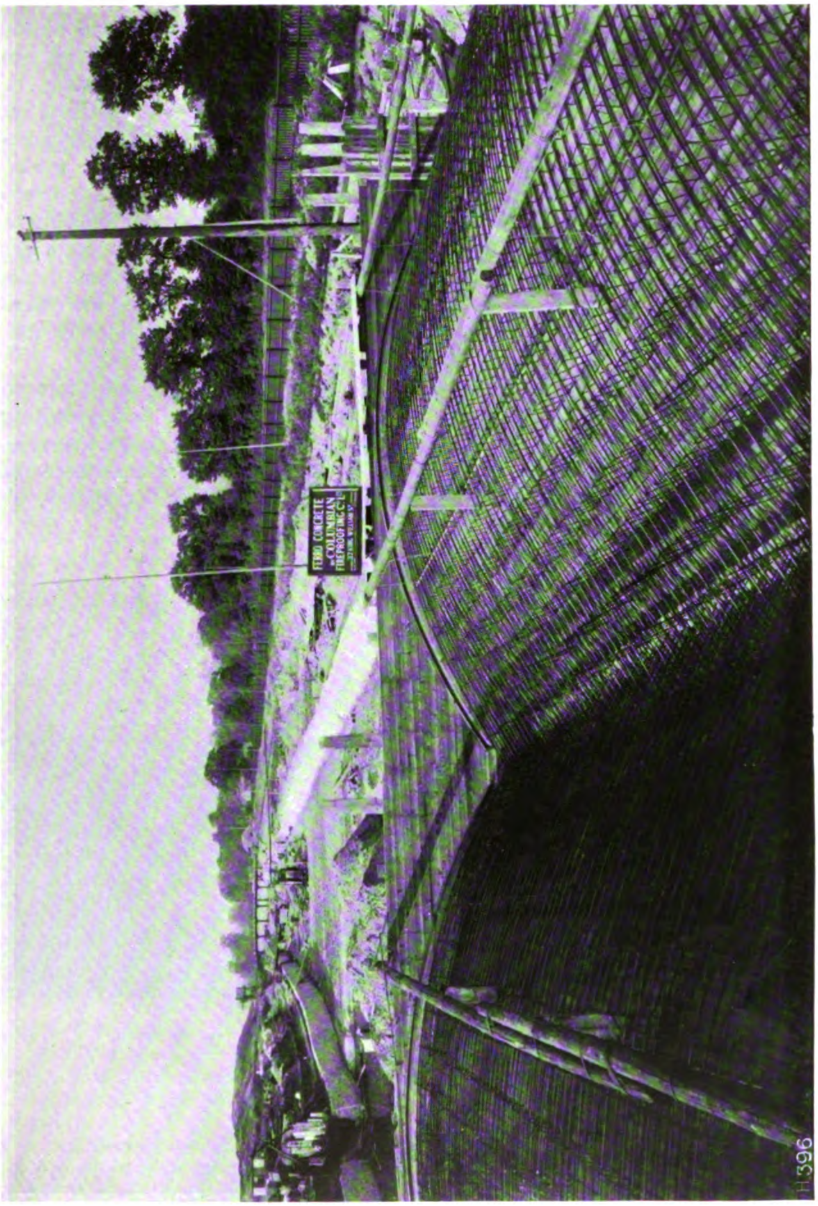
Side View of Bridge over the River Lea.

REINFORCED CONCRETE BRIDGE AT CHINGFORD.



Reinforced Concrete Bridge at Chingford.

seven in all, is being carried out by the Columbian Fireproofing Co., Ltd., of 37 King William Street, E.C. Round steel rods of various diameters are used in all cases for



View showing Reinforcement of Arches.
REINFORCED CONCRETE BRIDGE AT CHINGFORD.

the reinforcement. The decking, parapets, water towers, etc., in connection with these bridges were also included in the contract.

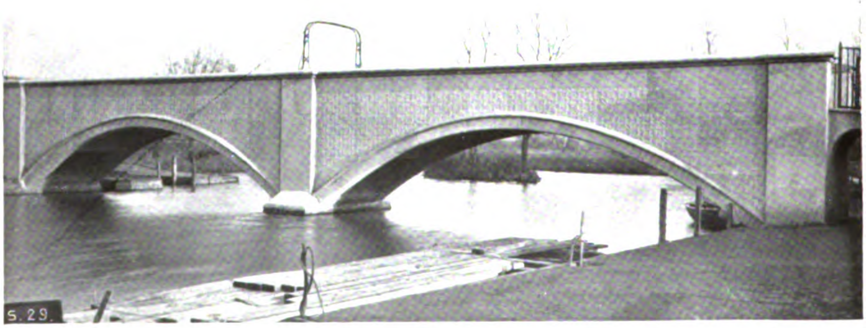
REINFORCED CONCRETE BRIDGE AT NORWICH.

THE illustration we show is of a reinforced concrete bridge across the River Wensum recently erected by the Norwich Corporation, Mr. Arthur E. Collins, M.Inst.C.E., City Engineer, supervising the work.

The new Dolphin Bridge, which was formally opened by the Mayor of Norwich recently, is in substitution for the old ferry and path and forms a considerable improvement upon the lines of the previous path leading from the river at this point.

The work had to be prepared as far as practicable in the winter time, and in order to obtain a fair appearance the visible portions were cast as slabs or in other convenient forms and used instead of boards against which to mould the *in situ* work. The slabs forming the spandrills and outer sides of parapets were moulded face downwards on mould boards provided with the reverse of the diaper pattern showing in the illustration. As soon as the concrete would stand firmly the slabs were removed from the moulds and scrubbed with stiff brushes and water to remove the cement from the surface, leaving the white quartz gravel and sand showing, and forming a somewhat rough surface much like cut stone. The general appearance of the work is much like dressed granite.

The slabs referred to have $\frac{1}{4}$-in. wire reinforcements, and at most intersections of the wires there are ties of 20-gauge wire, the tails of these ties projecting well through the backs of the slabs and eventually being embedded in the *in situ* reinforced concrete when the latter is filled in. The visible surfaces of the arches were moulded in separate pieces and scrubbed similarly to the spandrils, placed on centres, and the concrete was then filled in.



REINFORCED CONCRETE BRIDGE OVER THE RIVER WENSUM AT NORWICH.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE RAILWAY SLEEPERS IN GERMANY.

WE have from time to time dealt with the advantages of reinforced concrete for railway sleepers, giving particulars and illustrations of those used in America, Italy, and Denmark, and we are now glad to record an instance where they are expected to do good service in Germany.

In that country timber is as yet not very scarce nor is iron very expensive, and thus wooden sleepers or the metal "tie" might be expected to hold their own for a considerable period. Nevertheless experiments are being made in different parts of Germany, notably in Saxony, where the railway authorities have just laid down a mile of track in which reinforced concrete railway sleepers have been used.

The new sleeper has been very fully described in our German contemporary, *Beton und Eisen*, and by the kindness of the engineers in charge of the work we are able to reproduce some photographs which have not previously been published.

In this instance, however, the circumstances are somewhat peculiar, as the track in question is for a street railway, and the conditions under which the track is required to do duty make the application of reinforced concrete very appropriate, as it is well known that the wooden sleeper decays all too rapidly in street railway work, and owing to the great amount of vibration laying the rails on a concrete bed has considerable disadvantages.

The line in question lies between Dresden and Kotzschenbroda, and was put down in two sections, 900 yards last year and 800 yards this year, under Mr. Kopcke and Mr. Bloss, engineers of the Saxon Public Works Department.

The reinforced concrete sleeper used was designed on the Italian model, but is somewhat simpler than the latter, and differs chiefly in the arrangement of stirrups between the top and bottom reinforcement. These stirrups are **U**-shaped, and are arranged in the section of the sleeper where

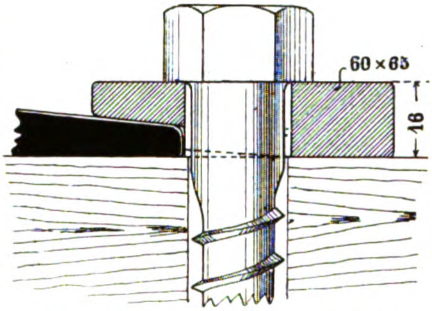


FIG. 1. IMPROVED FASTENING OF SLEEPERS.

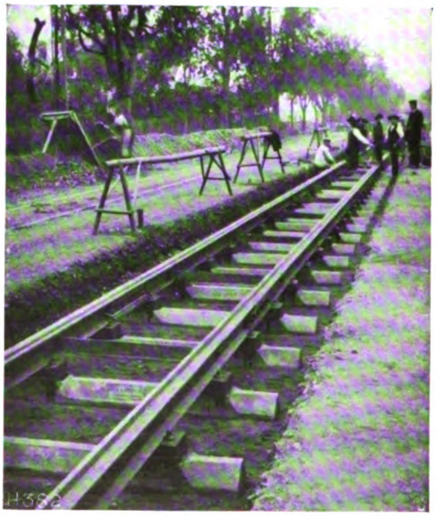
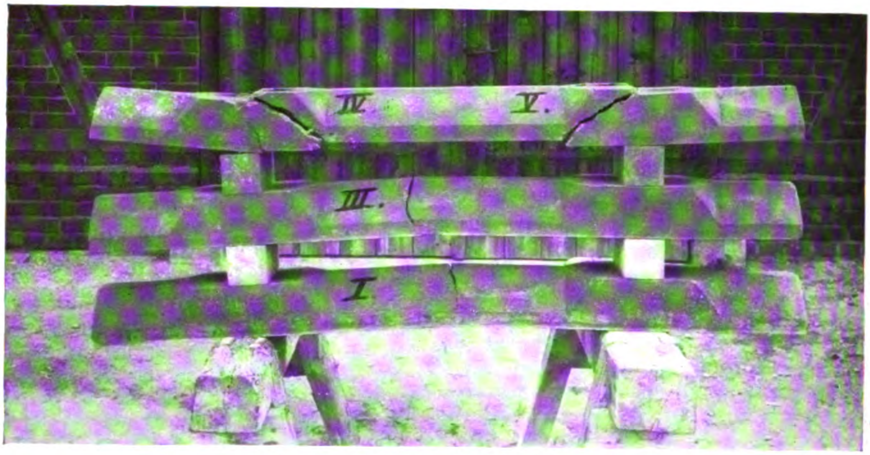
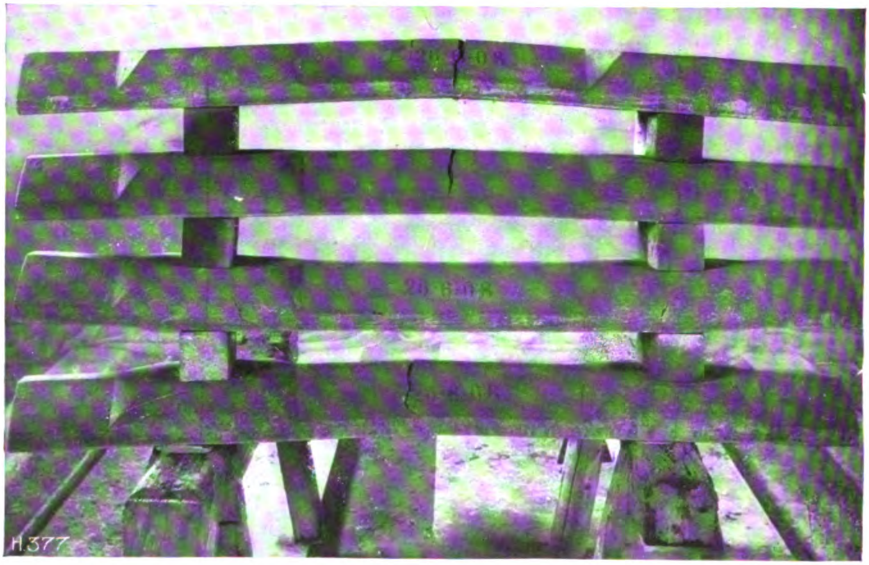


FIG. 2. VIEW SHOWING LINE BEING LAID.

the shearing stress is at a maximum. The wooden blocks intended to receive the screws do not reach to the bottom of the sleeper, but are only 4 in. deep, so as to be protected from moisture rising out of the ground. This also has the advantage of allowing the bottom reinforcing rods to be laid straight without being bent or curved to pass round the wooden blocks, and the part of the sleeper under the rail, where bending moments are most serious, does not require any openings. The holes for the wooden blocks begin near the neutral axis and the tensile stresses on the lower part of the sleeper are more favourably distributed. It has been proved by experience that 4 in. is sufficient for the wooden blocks.

Tests after 51 days.



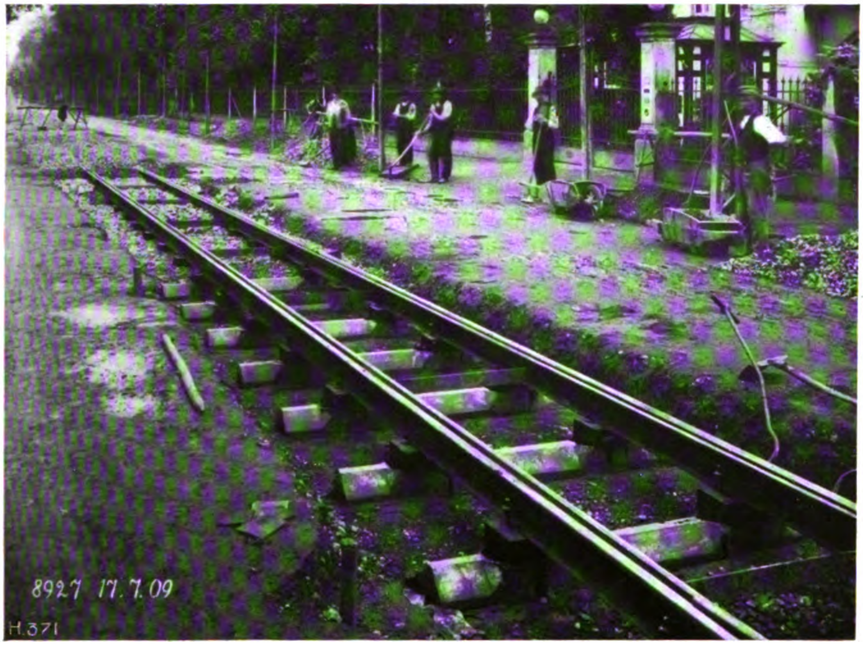


Tests after 237 days.

FIG. 3. TESTS ON REINFORCED CONCRETE SLEEPERS.

The sleepers are 2 yds. long and weigh 209 lb. each, $10\frac{1}{2}$ lb. being the weight of the reinforcement.

The concrete is composed of 1 part of cement to $2\frac{1}{2}$ of sand and finely broken stone. A block of oak 3 in. high is inserted between the sleeper and the rail in order



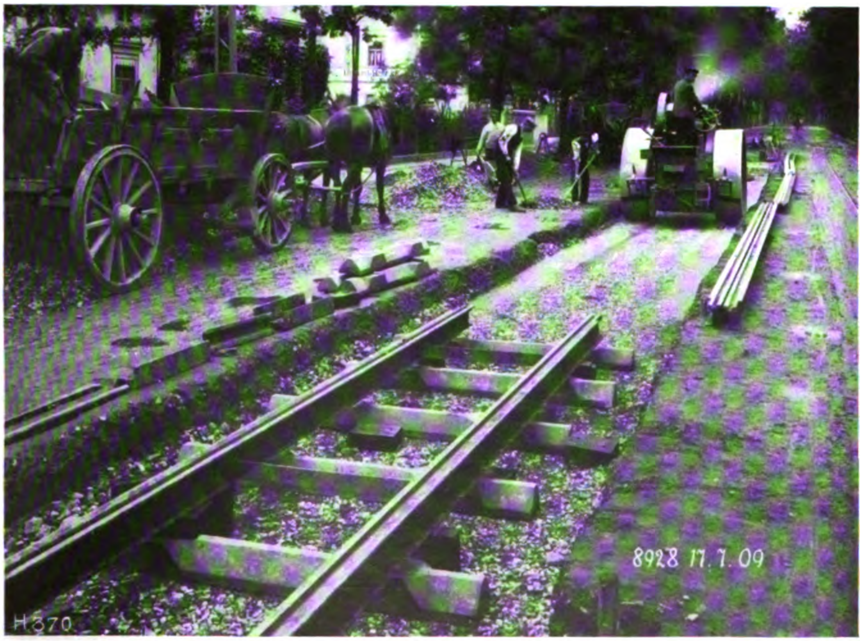


FIG. 4. REINFORCED CONCRETE SLEEPERS.
Views showing part of line from Dresden to Kotzschenbroda.

to make the top of the sleeper level with the roadway. This block has also the advantage, owing to its elasticity, of distributing the pressure over a larger surface of the sleeper.

The rails are fastened to the sleepers by 7 in. screws. The new sleepers to be laid down this year have an improved fastening, which is seen in *Fig.* 1. Clamps 2·4 in. long hold the foot of the rail.

Two sets of tests of these sleepers were undertaken by the firm of Dyckerhoff & Widmann, at Cossebaude, near Dresden, one series of tests after the sleepers had been allowed to set for 51 days, and the other after 237 days. With the load applied as at No. 2 in *Fig.* 5, it is noticed that in the first set of tests destruction was caused by sheer, while in the second set it was caused by tensile stress (see *Fig.* 3). The power of resistance was much higher with the second load (see *Fig.* 5), being nearly 2½ times as much, but the setting time did not make much difference, the results only being slightly better in the 237 days as compared with the 51 days.

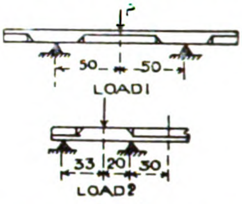


Fig. 5.
Showing Application of Load.

The test proved that the sleepers are of nearly the same strength throughout their length.

The further introduction of reinforced concrete sleepers will naturally depend on the time these sleepers last. In spite of the fact that at the time of writing that part of the track where the reinforced concrete sleepers have been longest in service has only been laid down a little over a year, yet it promises to give the same favourable results in the future. The road was broken up lately in some parts to examine the sleepers, and they were found to be perfectly intact. The screws are quite tight, and no corrosion was perceptible on the rails.

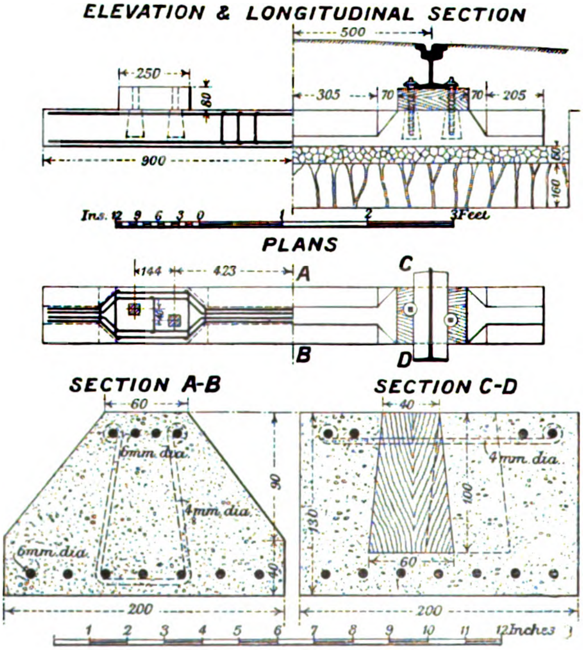
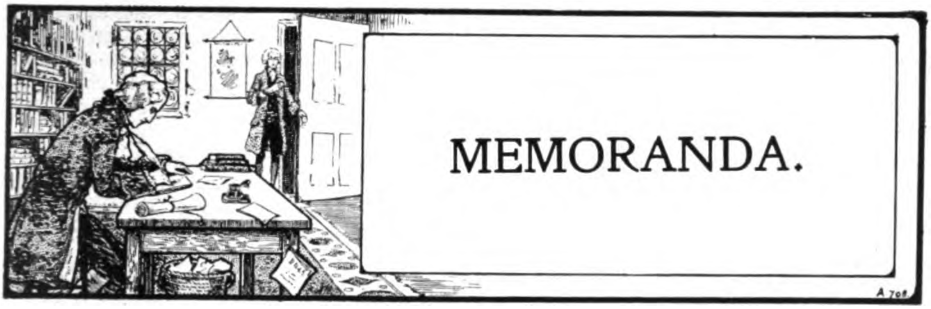


Fig. 6. Details of Sleepers.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

New Promenade at Margate.—The Margate Corporation have decided to expend the sum of £11,000 in constructing a new sea wall and promenade from Fort Point to the Clifton Baths, a distance of 1,050 ft. The promenade will be about 11 ft. above high-water mark, the height of the wall being 17 ft. above the level of the foreshore. The wall will be constructed of bull-nosed concrete blocks 4 ft. long, 2 ft. deep, and 2 ft. 9 in. thick. The top or coping blocks will be 2 ft. 9 in. deep, 4 ft. long, and 3 ft. deep. The blocks will be composed of one part of Portland cement to six parts of Brightlingsea shingle, and faced with four parts of Brightlingsea ballast to one part of Portland cement. There will be altogether eight courses of these blocks, backed up by concrete laid *in situ*, and the wall will have a thickness of about 10 ft. at the base and about 3 ft. at the top. It is proposed to make the promenade about 50 ft. or 60 ft. in width.

Reinforced Concrete Warehouse at Monte Video (Uruguay).—H.M. Legation at Monte Video have forwarded a copy of specification, plans, etc., in connection with an invitation by the Administration of the port of Monte Video for tenders for the construction of a reinforced concrete warehouse on Mole B of the port. Tenders will be received up to 3 p.m. on March 16th by the Consejo de Administración del Puerto de Monte Video, Cerrito núm. 185, Monte Video. The above-mentioned copy of specifications, etc., may be seen by British firms interested on application at the Commercial Intelligence Branch of the Board of Trade, 73 Basinghall Street, London, E.C.

Reinforced Concrete Pier at Broughty Ferry.—The reconstruction of the pier at Broughty Ferry carried out in reinforced concrete by Dundee Harbour Trust is now completed, and the official tests have proved satisfactory. The pier is for the landing of goods and passengers, and the cost of reconstruction was £2,850.

Castlewellan Waterworks.—The new waterworks at Castlewellan, Co. Down, have just been finished. Early in February last the first connections were made to the main, since which time practically the whole town has enjoyed an abundant supply of good water. Now that the storage reservoir and filter beds are complete no damage as regards either the quantity or quality of the water need be feared. The water is stored in a reservoir having a capacity of one and a half million gallons, or over 90 days' supply. This reservoir is square, with sloping sides, and is lined throughout with concrete; while between the top and bottom layers of concrete is a lining of bituminous sheeting. A steel gangway, resting at one end on a concrete pier, leads to the draw-off and scour valves. The filters are in duplicate, the filtering media consisting of four feet of stones and sand. A capacious clear water tank adjoins the filters, and is covered with a reinforced concrete roof with ventilators. The water is admitted to this tank from the filters, and is then drawn off to the town by a controlling valve. Air valves have been placed at all summits, with wash-out valves at all hollows, so that the danger of air-lock or block has been provided against.

Concrete at Parkhurst Prison.—Rapid progress is being made with the building of the wall at Parkhurst for the new prison. The wall, which will shortly be finished, is constructed of solid blocks of concrete, and is nearly a yard thick and 16 ft. high.

Teignmouth Sea Defence Works.—The chairman and surveyor to the Teignmouth Urban District Council are interviewing the Local Government Board with regard to a loan of £1,900 to carry out further sea defence works at the Point end. It is proposed to carry a new wall in concrete from the termination of the present contract wall to the groyne constructed by the Teignmouth Harbour Commissioners. The present sea defence contract is now on its way towards completion. The whole of the masonry work is finished, and reinforced concrete piles are being driven outside the wall to hold in the foundations.

Concrete Groynes at Hove.—The Town Council have decided that a concrete groyne and two timber groynes shall be constructed for the foreshore opposite King's Esplanade, between Brunswick Lawns and Mill's Terrace, at an estimated cost of £2,784. Tenders are to be invited.

Concrete for Sewage Works.—A contract for a scheme of main sewerage of Bentley Colliery and Rostall, Doncaster, has been let to Messrs. C. Bushby and Sons, of Leeds. The work, which has been designed by Messrs. D. Balfour & Son, of Newcastle-on-Tyne, consists in the laying of the whole of the sewers of cast iron pipes on a concrete bed, which is necessary owing to the treacherous nature of the subsoil. A pumping station is to be constructed of concrete, each of the storage tanks having a capacity of 2,000 gallons, from which the sewage will be automatically pumped by centrifugal pumps driven by electric motors. Floats are to be provided in the tanks so that when full of sewage the motors will be automatically switched on, the power for which is to be obtained from Bentley Colliery power station. The sewage is to be delivered at the existing disposal works, which are of sufficient size to take the increased quantity.

Egremont Ferry Pier.—The Wallasey Urban District Council have three piers and landing stages for dealing with the cross-river traffic to and from Liverpool—at Seacombe, Egremont and New Brighton. The Egremont pier was built about 30 years ago, and as it was found to be in a very dilapidated and unsafe condition, the council decided to replace it with a new and more convenient structure.

The old structure consisted of a high-level pier, 280 ft. long, with a low-level stage which was drawn up and down the slipway by hydraulic power as the tide rose and fell, the high-level pier and travelling stage being connected with a movable bridge. The whole of this arrangement has now been removed with the exception of eight shore spans, which have been practically rebuilt. The new structure has a high-level pier about 700 ft. long and 18 ft. wide inside the handrails; from the river end of the pier is attached a bridge 150 ft. long, the river end of which rests upon a floating stage 150 ft. long by 50 ft. wide.

The cast iron piles carrying the girders are all filled with reinforced concrete, and the deck of the pier is also of reinforced concrete. The kelsons of the landing stage are of the open braced web type, all parts being accessible for painting. The pontoons are of wrought iron strongly framed, and fitted with all necessary man-holes, pump-holes, and sounding-holes, the inside bottom being filled with cement concrete to the height of the floors.

The cost of the works in connection with the reconstruction was about £18,000. The contractors for the work were Messrs. Alexander Findlay & Co., of Motherwell.

Density of Concrete.—To determine concrete proportions for greatest density Mr. Albert Moyer, according to the *Journal of Gas Lighting*, suggests experiments with a receptacle holding 4 cub. ft., as, for example, a 15-in. sewer pipe. By using two or three sizes of crushed stone properly proportioned a denser concrete may be obtained, and cement and sand saved. If there are two sizes of stone, one passing a 1½-in. and the other a ¾-in. ring, the latter should be screened to remove all that will pass a ¼-in. screen, regarding this as sand. Then 2 cub. ft. of the smaller and a like quantity of the larger stone are well mixed and put into the pipe, and the top of the mixture marked on the side. A mixture of 2½ cub. ft. of the larger stone and 1½ cub. ft. of the smaller stone, and a number of other proportions, are then tried, and the one giving the least volume will give the densest and strongest concrete with the least sand and cement.

Reinforced Concrete in Fire.—An interesting report on the fire-resisting qualities of reinforced concrete has just been made by an adjuster for an insurance agency in Chicago. A building of this construction at South Elgin, Illinois, used for the manufacture of drugs, was recently subjected to such a fire that a total loss was claimed. It was contended by the adjusters that the concrete floors and ceiling were not sufficiently damaged to warrant their demolition, but the owner claimed that the concrete had been weakened by the intense heat, about 60,000 lb. of drugs having been consumed. It was finally decided to test the building by putting a weight of 400 lb. to the square foot on the panels, and it was agreed that they should be held defective if they deflected more than three-sixteenths of an inch, that having been the original test made by the architects when the building was turned over to the owners. Tests were made of eight panels involved in the fire, and all of them showed considerably more than three-sixteenths of an inch deflection when only 250 lb. to the square foot had been placed upon them. The same weight was applied to other panels of the building not affected by the fire, and the deflection was shown to be less than one-tenth of an inch. As a result of the test a total loss was allowed on six panels and a compromise effected on two panels. It was held by the adjusters that had the building been of any other construction than concrete it would have been totally destroyed on account of the great heat engendered by the burning of the drugs and chemicals. The conclusion reached was that the weakening of the concrete was caused by the expansion of the steel reinforcement under the intense heat.

Bonding New Concrete to Old.—*Mr. Albert Moyer, Assoc.Am.Soc.C.E.*, gives the following method of bonding new concrete to old :—Clean off with clear water and stiff broom the surface of the old concrete. Mix one part commercial muriatic acid or hydrocloric acid and three parts water, or use bonsit or ransonite, mixed according to directions with hot water, make several applications one after another with a brush containing little or no metal. This will not injure the concrete as the acid does dot sink to a sufficient depth before it is neutralised. This will have the effect of removing the cement from the top surface of each grain of sand or piece of stone and the other aggregates that may have been used, exposing the clean surface of these aggregates in exactly the same condition as they were before being mixed. After applying the acid wash the surface with clear water, scrubbing with a stiff broom or brush, removing all the dead particles. While the surface is still wet (and it should be thoroughly wet) apply the new concrete. Protect this new concrete by keeping it damp for at least a week. Do not let it dry out at any time during the first week. It will be found that the new concrete will bond to the old as strongly as if both had been mixed at the same time.

Another method of bonding new concrete to old was recently described by Mr. Frank Barber, of Toronto, in the *Canadian Engineer*, which consists in placing bags of cracked ice on the last surfaces of concrete placed at night, thus reducing the temperature of the concrete, and, consequently, retarding its time of setting, so that on the next morning the surface is still plastic, and the concrete then placed will set in one mass with the old. The invention of this scheme is credited to Mr. O. L. Hicks, when he was contractor for a reinforced concrete truss bridge in Ontario. As all of the members in these trusses were of relatively small cross section the ice bags were easily placed in position at the end of a day's work, and it is stated that the method worked very successfully. To what extent it could be applied to heavier work is not as yet known.

Coke and Stone for Concrete.—Some interesting comparisons of the respective merits of coke breeze and stone for utilisation in concrete have been made by the engineer of a coal and coke company in Elkhorn, Virginia. In order to obtain the figures in connection with the coke breeze some small columns, 8 in. in diameter and 30 in. long, were made for employment as props in mines. The breeze weighed 27 lb. per cub. ft., the specific gravity was 0·905, the percentage of voids was 49·28, and the water absorption was 30·9 per cent. Ordinary qualities of cement and sand appear to have been used, the mixtures of cement, sand, and breeze, four in all, being respectively 1-2-3, 1-2-4, 1-2½-5, and 1-3-6. The results of the tests were obtained with a Riehle 400,000-lb. machine, the deformations being read from micrometers. With one exception the initial loads were 1,000 lb. with increments of 5,000 lb. The results showed that the average breaking load of three columns made with the first mixture was 85,567 lb., with the second mixture 88,167 lb., third mixture 79,334 lb., and fourth mixture 59,750 lb. The average unit strength in lb. per sq. in. in each case was 1,699 1,752, 1,576, and 1,187. The figures for the stone concrete were obtained from Professor E. J. McCaustland at Ithaca. In this case the mixtures were 1-2-3, 1-3-4, 1-2-5, and 1-3-5, and the average breaking loads respectively were 151,000 lb., 122,200 lb., 128,000 lb., and 120,933 lb., the average unit strength being 1,872, 1,472, 1,483, and 1,504.

Although attention is drawn to the facts that iron and steel rapidly corrode when in contact with wet coke, and that the coke itself is likely to disintegrate, the coke breeze concrete is held to have demonstrated its suitability, except under water, for all cases where stone concrete is used, especially as it is much lighter.—*Times Engineering Supplement.*

CATALOGUES, ETC.

The Combined Concrete Construction Co., Ltd., 41 Finsbury Pavement, E.C., have sent us a copy of their new catalogue indicating their various systems of construction. We must congratulate the company upon the unique character of this production, which is excellently got up and printed, a very special feature being the hand-coloured drawings which are shown on separate sheets facing the letterpress of each page. Among the various specialities described and illustrated may be mentioned reinforced concrete and hollow tile roofs, reinforced concrete tubular floors, " dry system " (no centering), patent reinforced hollow tile fireproof floors, and bridle suspended reinforced concrete fireproof floors. The last-named consists of British steel tees suspended in patent bridles over the top flanges of steel joists and main girders, or resting on wall bearings. The " Bridles " in which the tees are suspended are made from various sizes of round steel rods of sufficient thickness to support the slab or beam. In bridle-suspended floors the sides of the rolled steel joists or girders are completely encased in concrete, the underside being covered with reinforced concrete fixed to lower flange. The patent bridle is claimed to be of great advantage in case of fire, and also to bind the several floor slabs together. This catalogue will be a useful and ornamental addition to any technical library.

CONTRACTS.

Messrs. Edmond Coignet, Ltd., Victoria Street, S.W.—Among the structures which this firm have at present in course of erection are the following :—Money Order Department for H.M. Office of Works, Holloway; new Joiners' Shop for the Admiralty, at Portsmouth; Factory at Bailiff Bridge, near Leeds; new premises at Infirmary Street, Leeds; new Kingsdown Schools, Bristol; new schools, Tiverton, Devon; Newport Road Intermediate School for Boys, Cardiff; new premises for Grossmith & Son, Paternoster Square, London; Administration Block, Cottages, etc., at Kinlochleven; Foundations for Fulham Temperance Billiard Hall; Public Buildings and King's House at Kingston, Jamaica; Floors for Victoria Works, Leeds; Livingstone Hospital at Dartford, Kent; Bridges at Saltley, over River Rea, Birmingham.

J. & W. Stewart, Belfast, have recently secured the contract for the construction of new sedimentation tanks, which has been placed by the Belfast County Borough Improvement Committee in connection with main drainage purification works. The new tanks will be of reinforced concrete, carried on a pile foundation, and will have a capacity of 3,000,000 gallons.

Messrs. Stuart's Granolithic Co., Ltd., have recently entered into contracts for the following works: Metal and munitions factory, Birmingham ; German Y.M.C.A. Buildings, City Road, E.C. ; residential flats, Southport ; maltings, Ipswich ; High School for Girls, Barnsley ; Surrey Reservoir, Polesden Lacey ; confectionery factories, Stockport ; new buildings, Paternoster Square (Coignet system) ; North British and Mercantile Insurance Buildings Waterloo Place, London ; Oleo factory extensions, Barking ; Horbury Bridge Mills, Dewsbury ; Buttershaw schools, Bradford ; Queen's High Cliffe Hotel, Margate ; bacon factory, Bristol ; reservoir, Drynham, Surrey ; factories for British Drug Houses, Ltd., Graham Street, E.C. ; Doulton Road School, Cradley Heath ; engineers' shops, L.B. & S.C. Railway, Brighton ; Y.M.C.A. Buildings, Blackburn ; jam factory, Ely ; St. Benedict's Church, Birmingham, domes, roofs, and arches ; Westminster Mansions, Old Queen Street, S.W. ; London & South Western Bank, Aldgate, E. ; silos and granaries, Hull (second contract) ; Royal Hospital, Sheffield ; Moore & Robson's Brewery, Hull ; garage, Wimbledon ; seed silos and warehouse, Selby ; Henley's Telegraph Factory, Woolwich ; silk factory, Coventry ; pumping station, Epping ; new factories, engine house, etc., Hayes ; biscuit works, Willesden ; racecourse stands, Kahn system, Mullingar ; St. Anne's Church, Buxton ; furniture depositories, Shrewsbury ; reconstruction Freemasons' Tavern, London ; High School for Girls, Bridlington ; offices, Dartmouth Street, S.W. ; school for local authority, Tamworth ; Upper Wyche Church, Malvern ; silk mills and factories, Flint ; bridges, Ward, End Park Birmingham ; navigation mills, Blackburn ; Victoria Institute, Worcester ; bakery, Worcester ; Town Hall extensions, Leicester ; reservoir, Wallingford ; Hippodrome Theatre of Varieties, Preston ; Queen's Hotel and Mansions, Margate ; stables and offices, Beaumaris Street, Liverpool.

CORRECTION.

In the article on "Concrete Tubes as Sewer Pipes" in our December issue the diameter of the pipes supplied by the Imperial Stone Co., Ltd., was given in error. This Company manufacture concrete pipes from 15 ins. to 48 ins. diameter.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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EDITORIAL NOTES.

REINFORCED CONCRETE IN THE METROPOLIS.

ALL interested in reinforced concrete are anxiously awaiting the impending issue of the draft regulations for that material which are to be prepared under the London Building Act as amended last year, and it is to be hoped that every possible effort will be made to accelerate the preparation of this draft, seeing that even when it is complete the procedure to be adopted before the regulations can finally come into force is almost sure to be a lengthy one, for they have to be referred not only to the Local Government Board but also to various technical societies for review.

The matter is not only of importance to the metropolis and those who attend to buildings in the county area, but to the whole country, for we may be sure that whatever is finally adopted for London will practically serve as a model for many other large centres, and will also be a guide for the rural districts.

In two directions we think that something might be done in these proposed regulations to assist in a general standardisation of the practice of reinforced concrete. In the first place, we think that, whatever may be the standard algebraical notation finally recommended by the Concrete Institute, this notation should be adopted as far as possible for calculations required under the new regulations: secondly, we think there should be very precise instructions as to drawings, the manner in which they are to be prepared, how they are to be figured and annotated, etc., so that we may practically obtain some standard method in the preparation of reinforced concrete drawings, in respect to which there is much confusion at the present moment.

REINFORCED CONCRETE CHIMNEYS.

THE Concrete Institute devoted its January meeting to the consideration of a paper on reinforced concrete chimneys, and we give a lengthy summary of the paper and discussion under "Recent Views" in this issue.

The subject is one that claims more attention than it has so far received. It was, of course, regrettable that those specialist designers of reinforced concrete chimneys who came over from America met with so little success in this country, and had to discontinue their work here owing to lack of support, for during the short period in which they were in operation the chimneys that were erected under their supervision were certainly of a satisfactory character. The reinforced concrete chimney is essentially economical where large chimneys have to be erected and where there is little space for their foundations.

It is a matter that some of our leading builders and also some of the reinforced concrete specialists would do well to look into, for the moment our industries begin to look up there will be a large field for chimneys of this description.

STANDARD DRAWINGS.

In our last issue we dealt with the question of standard notation as suggested by the Concrete Institute. In this number we publish an article on the standardisation of drawings.

We, who see so many drawings of reinforced concrete work prepared both by members of the technical professions and by specialist designers, are somewhat surprised at times at the extraordinary divergence in the practice adopted in preparing the necessary sheets. There is great confusion among the professions on this point. In many cases much unnecessary drawing is done, and there is no similarity in the character of the figuring or description of the work.

A great saving of time and labour would be effected, and it would be a boon. indeed, to all concerned, and particularly to those who supervise the execution of buildings, if a standard form of drawings were eventually adopted. We are glad to note that one of the Standing Committees of the Concrete Institute is taking up this matter, and we trust that they will arrive at a satisfactory solution of the problem.

CONCRETE AS A FIRE RESISTANT.

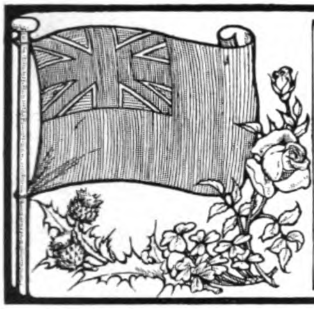
The recent fires in drapery stores should remind architects of the absolute necessity of protecting all steel work with concrete, no matter whether this covering be laid down in the local regulations or not.

Unprotected steel-work is very dangerous, but if properly protected it is a safeguard of the highest order. Under the London Building Act Amendments of 1909 the protection of steelwork has been ordered for certain classes of buildings, and it is to be hoped that eventually this requirement will become a general one. There is no doubt that in buildings of the type affected by the fires named the protection of the steelwork would have meant a considerable reduction in the loss of life and property.

Building owners should not overlook the advantage of the use of reinforced concrete, and it was particularly noticed that the concrete parts of the two stores recently burnt down offered much greater resistance to the fire in each instance than the ordinary brickwork.

In the case of the fire at Messrs. Arding & Hobbs the Inspector of Factories emphasised the fact, upon examination, that the concrete staircases stood very well, and that they were still quite firm, whilst the District Surveyor in his evidence gave it as his opinion that "had there been concrete floors, and had the ironwork been encased in cement, the goods only would have taken fire, and the fire would soon have been put out."

Directly the new building regulations referred to above have been decided upon there can be no doubt that clear-sighted owners of large enterprises will make a greater use of this material than heretofore.



CONCRETE AND REINFORCED CONCRETE AT THE ROYAL AUTOMOBILE CLUB'S NEW BUILDING.

In view of the importance of the new premises now being erected in Pall Mall for the Royal Automobile Club, we intend presenting a series of articles on this structure. The present one deals principally with the work in its initial stage. Later on we shall give particulars of the building when it is more advanced, finally describing the finished structure. These articles are being prepared for us by Mr. Albert Lakeman, Hon. Medallist Construction, Lecturer at the Woolwich Polytechnic.—ED.

THE important building now being erected in Pall Mall as the new club house for the Royal Automobile Club, contains many interesting forms of construction, one of the chief features being the concrete and reinforced concrete work.

The site, 228 ft. by 140 ft., is that formerly occupied by the old War Office buildings, with a frontage to Pall Mall, while the rear adjoins the Carlton Gardens.

The new building which is being erected from designs by Messrs. Mewes & Davis and Mr. E. Keynes Purchase (the joint architects), will have eight floors in all, including two floors which come below the pavement level. The retaining wall at the rear of the building, next the Carlton Gardens, is constructed in reinforced concrete, and a few details of its construction should prove interesting.

The total length is about 200 ft., and the height, which varies, is roughly about 35 ft. The soil which it had to support, being loose gravel with a great tendency to slide, required very careful shoring during the execution of the work, and particularly as the bottom of the wall in some cases comes below the surface water level. Some idea of the elaborate strutting that was required can be gathered from the illustration (*Fig.* 2) which also depicts a portion of the site at the rear, and some of the trenches required for the grillage foundation can be seen at this point forming as they do a very large excavation.

In designing the wall, very little projection was possible on the side next to the gardens, and consequently a small heel projecting only 2 ft. 6 in. was formed, whilst the toe projects under the new building to the extent of over 12 ft. in some cases. One of the chief difficulties occurred next the swimming bath, which is being constructed in the basement, as it was necessary to erect the retaining wall in the first instance, and carry out the excavation for the bath at a later date. Owing to the depth required for the bath, this excavation came below the bottom of the reinforced wall, and it was necessary to take great precautions to prevent the possibility of any sliding, especially as the work was well below the surface water level. The line of excavation is shown on the drawings of this wall (*Fig.* 3), and it will be noticed that the actual foundation to the wall was carried down to the level of excavation required for the bath, and a large mass of 12 to 1 plain concrete filling employed to form a firm base to the wall and obviate any movement taking place when the surrounding soil was removed. At all other portions of the wall the foundation is simply formed

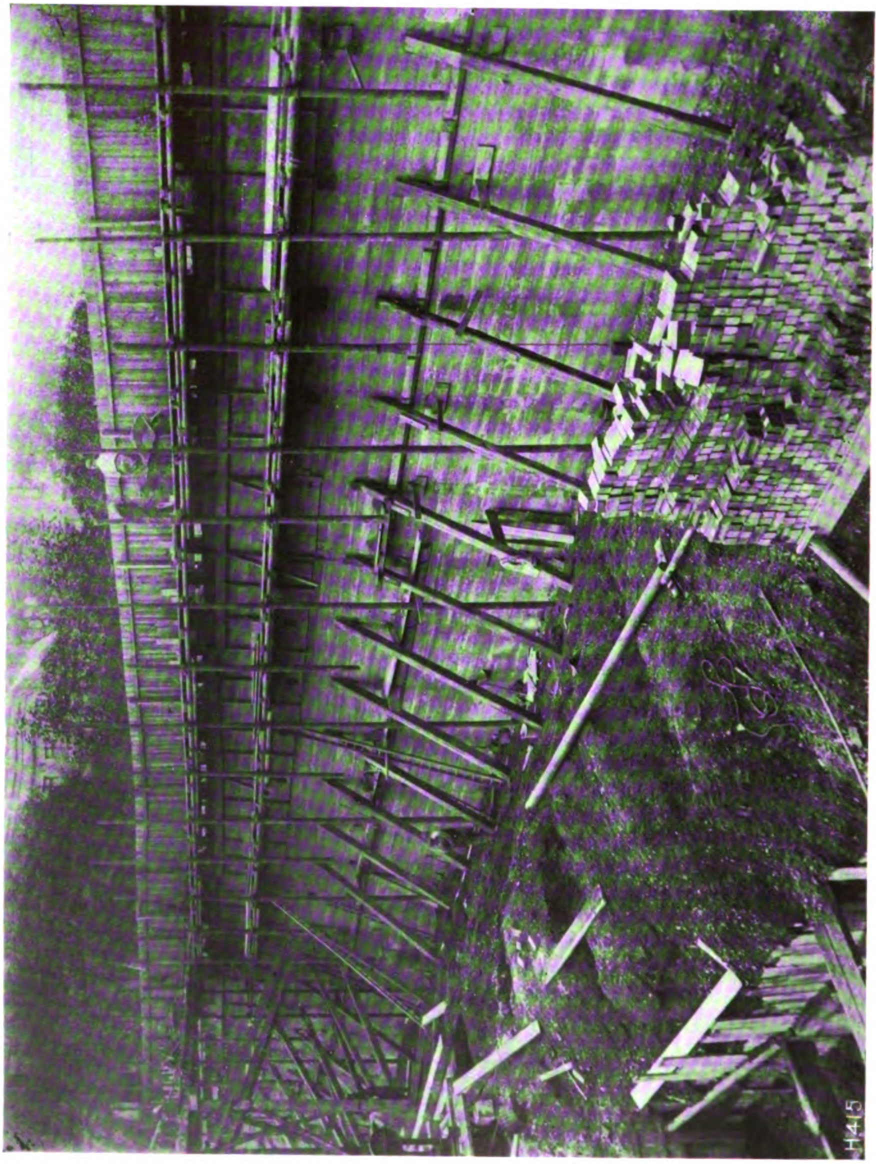


Fig. 1. The completed reinforced concrete retaining wall.
New Royal Automobile Club.
[*"Building World" Copyright Photograph.*]

with 12 in. of cement concrete, in order that the asphalt damp course could be applied, and upon this the base of the wall is directly carried. This asphalt damp course is worthy of note, being continuous under the whole building and passing under all walls, grillages, and floors, as can be seen from the drawings. The thickness employed was ½ in. under all floors, and ¾ in. under walls and grillages and in vertical positions. Brick walls were built where necessary for the application of the vertical layers as shown.

Fig. 5 is an interesting one, which shows the foundation to the reinforced wall after it had been prepared and asphalted, and although the full length of the wall is not shown, some idea of the size can be gathered. The stepped portions form an excellent abutment for the base of the wall, and prevent any sliding on the asphalt, and this was particularly necessary where adjoining the swimming bath. The actual height and section of the wall varies at different points, there being practically three different heights, two of which are illustrated in the drawings, and the third is 2 ft. less than that which was required near the swimming bath.

In all cases the wall has a vertical face next to the gardens and a battering face towards the new building. The thickness of the wall at the base next the plunge bath (where the greatest height was required), is 3 ft. 6 in., and it tapers to 13½ in. at the top. The thickness of the heel varies from 4 ft. to 3 ft. 6 in., while the toe is diminished as shown.

The concrete employed was composed of good ballast and Portland cement in the proportion of 1 and 5, the whole being mixed by machinery and well rammed in position. The reinforcement is provided by indented steel bars of ¾ in. and 1¼ in. section spaced at distances, horizontally and vertically, varying from 6 in. to 24 in. centre to centre, and the vertical bars in the wall are carried into the heel and toe in different forms as shown. Some of these bars were of such a length and shape that it was found impossible to cart them to the site in the shape required, and they were consequently sent to the building and afterwards formed to the various curves by bending in a hydraulic press, three bars being operated upon at a time. The shuttering for the back of the wall and the method of spacing the reinforcement can be seen in *Fig.* 2, where some of the vertical bars are seen in position. The horizontal notched timber was fixed to allow a covering of 2 in. to the main reinforcing bars, and small pieces of brick were placed under the foot of the bars to allow the same thickness of concrete at the bottom of the wall. Where it was necessary to join bars that were continuous, as in the case of the horizontal reinforcement, the bars were made to overlap and a splice formed 6 ft. long.

Although not necessary for purposes of strength, all vertical and horizontal bars were wired together where crossing one another, before any concrete was filled in, the object being to prevent any possible displacement of the reinforcement, this naturally being a very important matter, and although this system entailed some 15,000 wirings, it is certainly the best method of executing the work.

After the wall had dried sufficiently, the shuttering at the back was removed

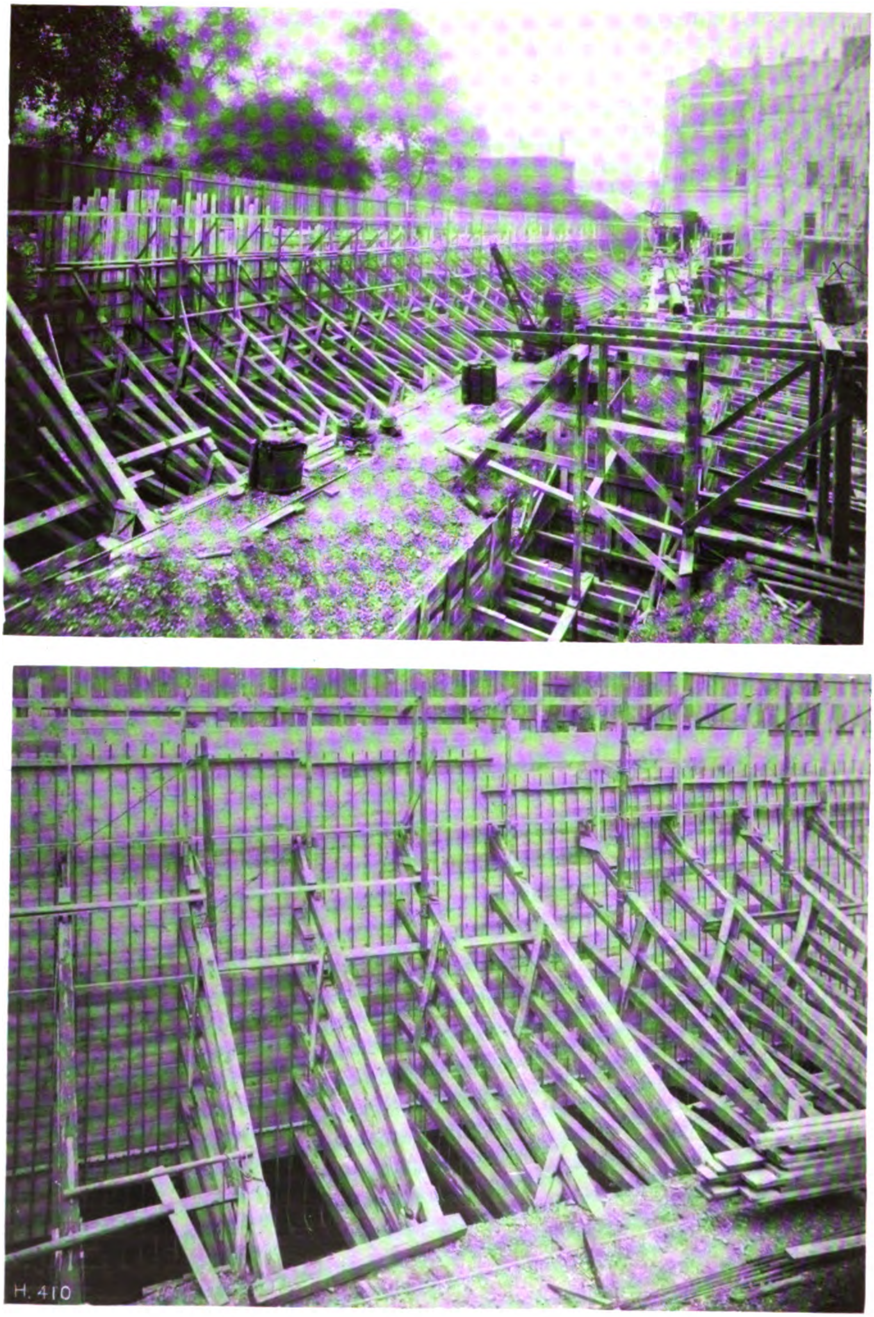
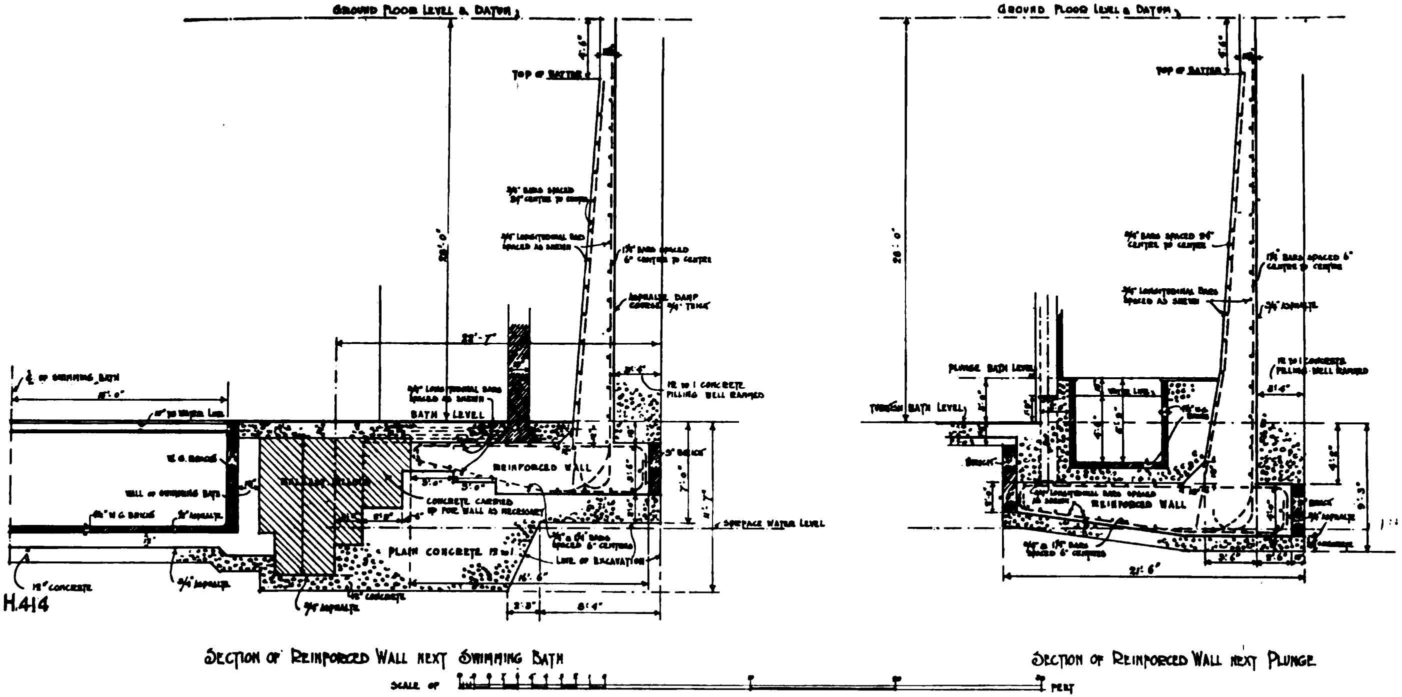


Fig. 2. Views showing timbering for reinforced concrete wall.

NEW ROYAL AUTOMOBILE CLUB.

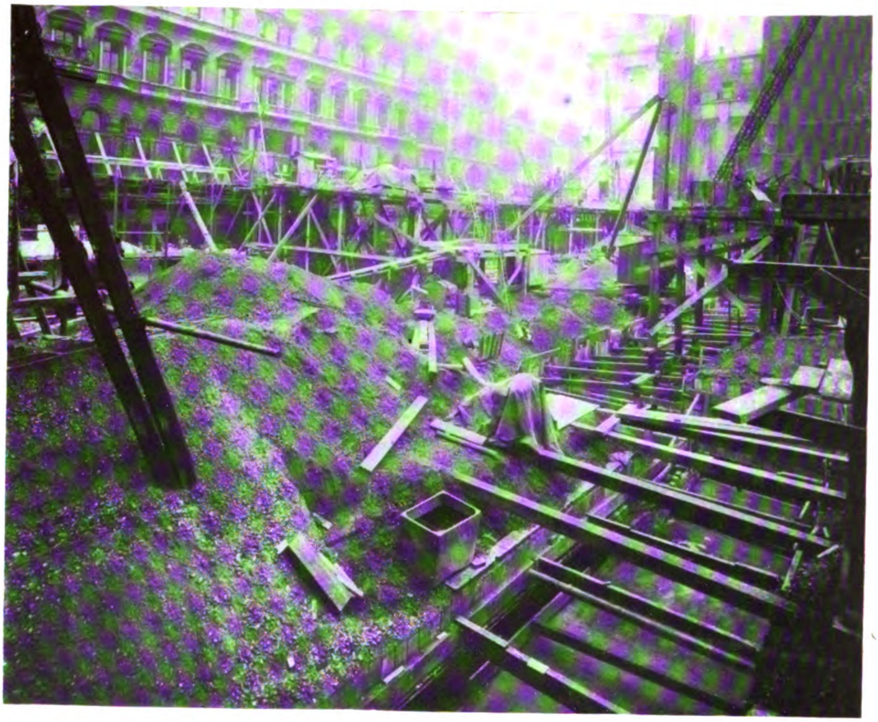


SECTION OF REINFORCED WALL NEXT SWIMMING BATH

SECTION OF REINFORCED WALL NEXT PLUNGE

Fig. 3. Drawings of reinforced wall.
NEW ROYAL AUTOMOBILE CLUB.

Fig. 4. View of front portion of site.



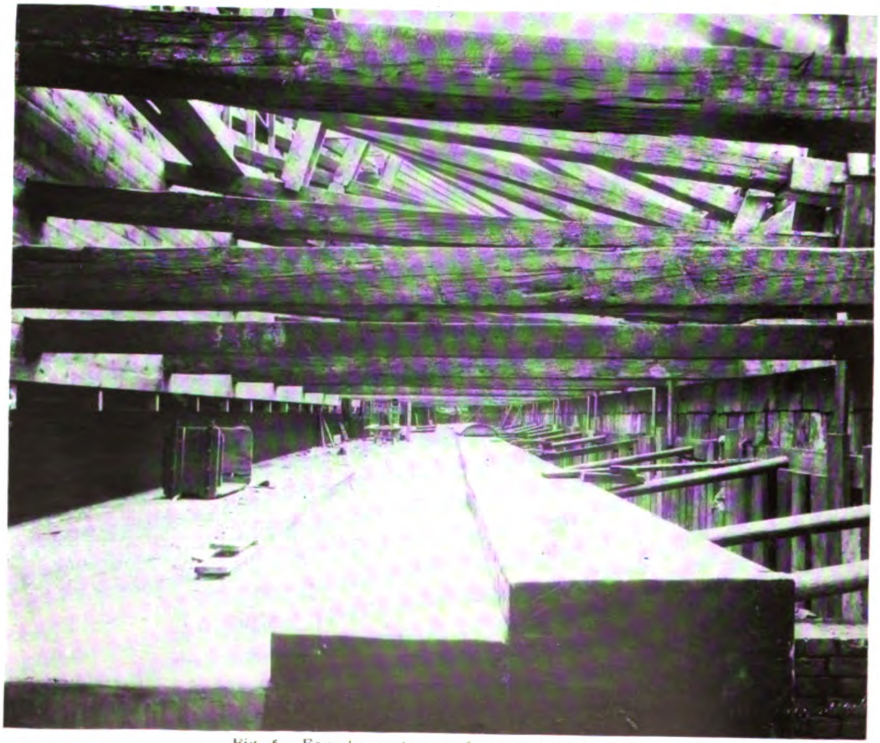


Fig. 5. Foundation for reinforced concrete wall.

New Royal Automobile Club.

and the vertical asphalt applied to the whole surface before filling in with the 12 to 1 concrete well rammed into position. The completed wall is shown in *Fig.* 1.

Six weeks were allowed to elapse after the concrete had been placed in position in the wall before the first tier of struts was removed. As each strut was withdrawn the holes were carefully filled up with cement concrete, and seven days' interval was allowed between the removal of each tier in order that the weight coming upon the wall might be gradually applied.

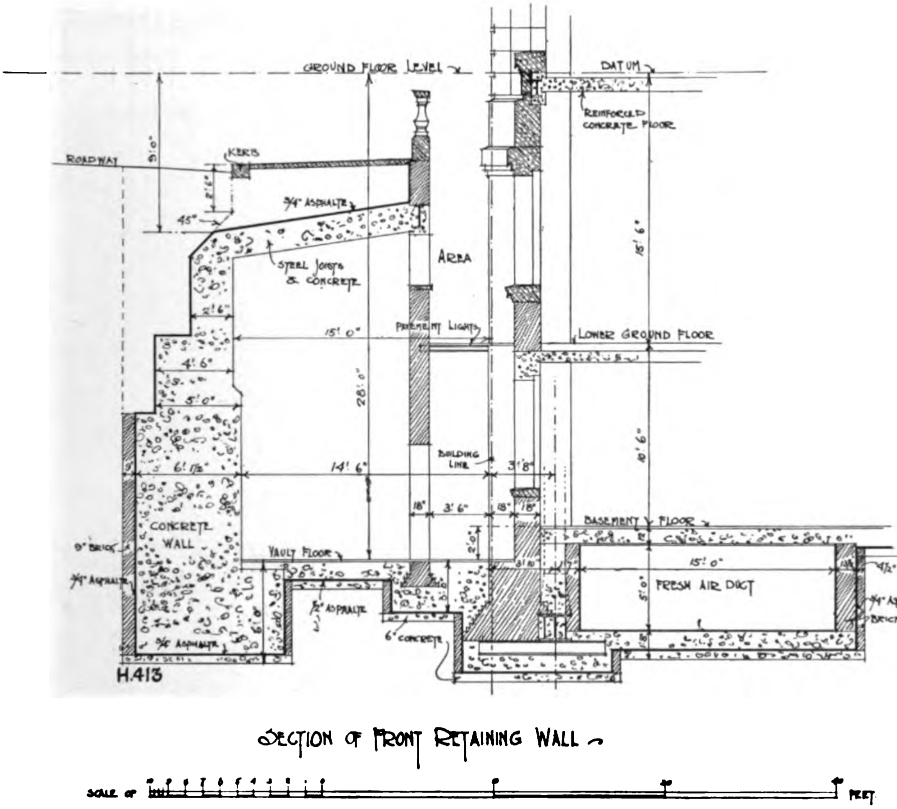


Fig. 6. Drawing of front retaining wall.

New Royal Automobile Club.

The front retaining wall affords an excellent example of plain concrete work, and it is very interesting to compare the two walls. This wall extends along the whole frontage to Pall Mall, forming the outer wall of the vaults, which come under the pavement, and supporting the roadway for a length of 228 ft. and a height of nearly 30 ft. As the space in the front vaults was not so valuable as that at the rear of the site, it was decided to use plain concrete, although it was found necessary to employ a wall with a thickness of 6 ft. at the base. At the same time the work could be executed with great rapidity, and this was an

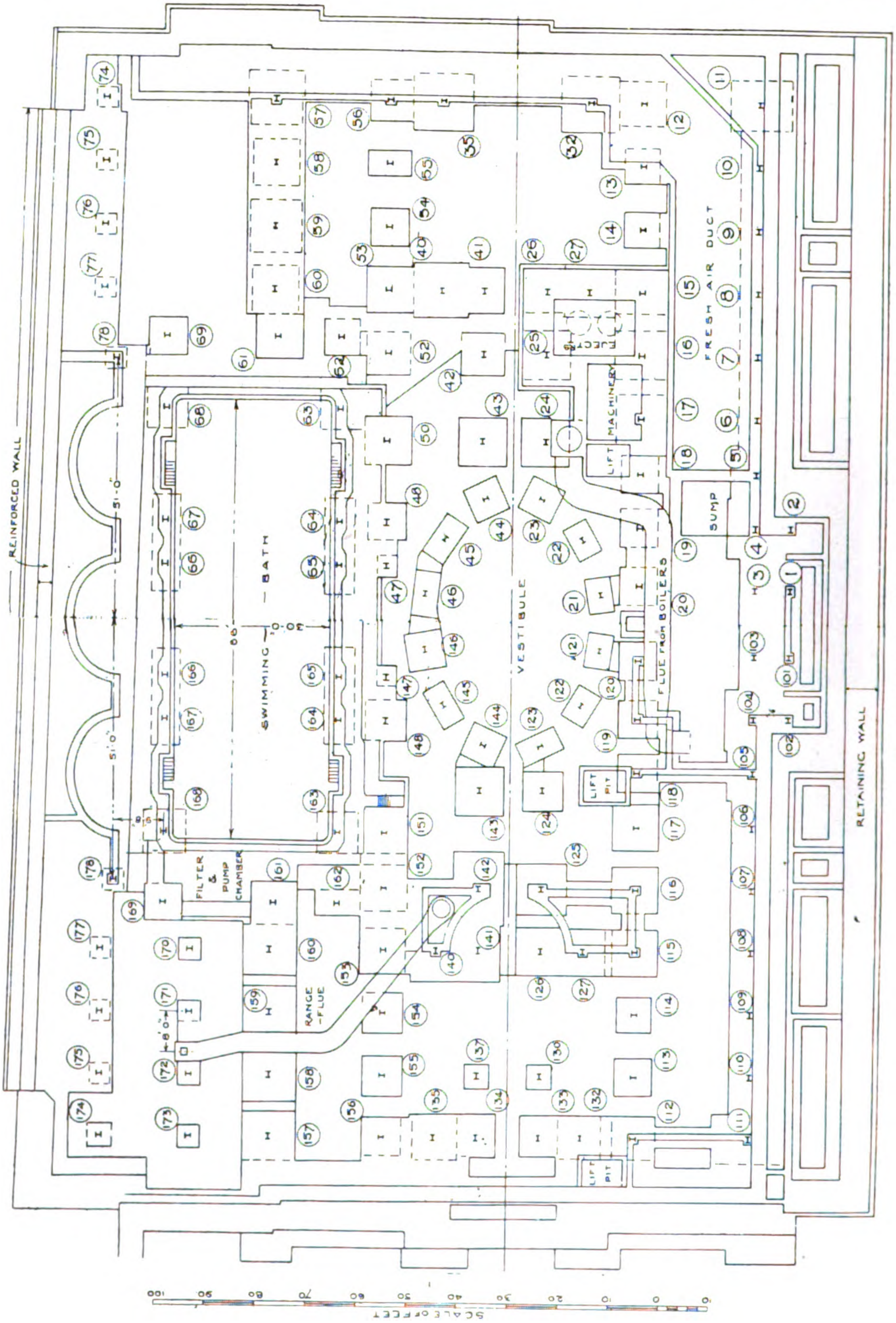


Fig. 7. Foundation plan.
New Royal Automobile Club.

important factor in such a position. The line of excavation is shown on the drawing of this wall (*Fig.* 6), and it will be seen that it was necessary to build up a 9-in. brick wall for a portion of the height in order to apply the vertical asphalt damp course on the outside of the retaining wall. There are two offsets at the back of the wall next the roadway which reduce the wall from 6 ft. at the base to 5 ft., and 2 ft. 6 in. respectively. There is also one offset of 6 in. inside the vaults, this break occurring at the floor level wherever the lower ground floor is carried through into the vaults. There is no heel to the wall, but only a short toe which projects about 2 ft. 6 in. under the vault floor. The concrete used in this wall was composed of good ballast and Portland cement in the proportion of 6 to 1. It is interesting to note that 30,550 cu. ft. of concrete were required for the construction of this wall alone. The greatest care had to be exercised in supporting the numerous mains that came in close proximity to the work, and the shoring required was of the most elaborate character. A portion of the finished wall can be seen in *Fig.* 8, and some of the timbering is also shown. The sloping roof to the vaults, shown on the drawing, was constructed of rolled steel joists and concrete. A portion of the underpinning to the walls of the Carlton Club (which adjoins the new building on the east side) can be seen in *Fig.* 8, and this work involved a great amount of material and labour. The thickness of the walls that were underpinned, in some cases, reached as much as 6 ft., and the width of the concrete bed required under the new and old walls was 21 ft. in some instances.

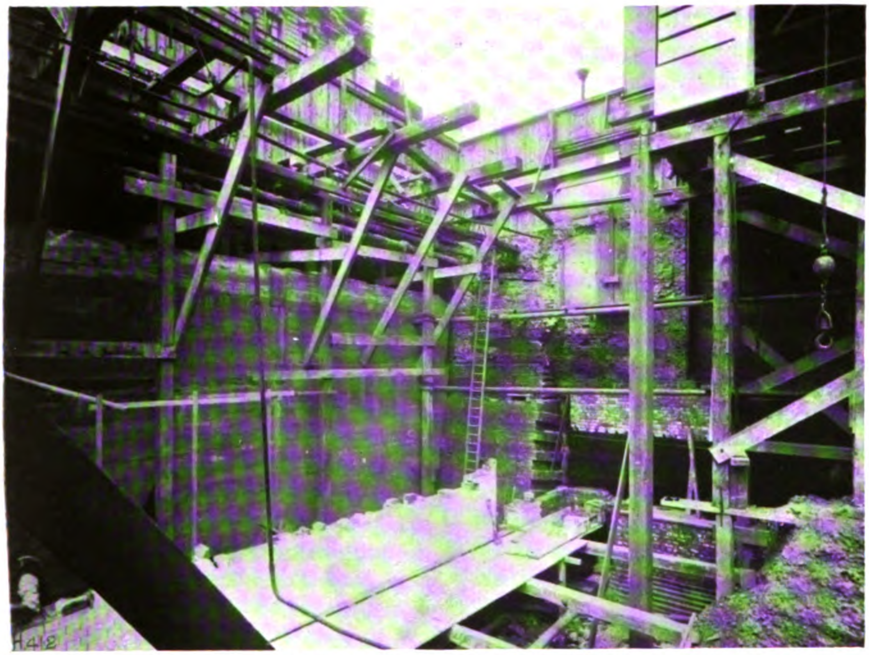


Fig. 8. Underpinning the walls of the Carlton Club.
New Royal Automobile Club.

There are several other retaining walls of more or less importance, and they were all constructed of plain concrete. The largest of these are the walls forming the special chamber constructed below the basement floor to contain the ejectors which will be employed to raise the sewage. The size of this chamber is 15 ft. 9 in. by 11 ft. in the clear, and the depth over 20 ft. below the basement floor level. The greater portion of this work being below the surface water level, great care was necessary during its execution, and steel piling was employed in place of the usual timbering to support the sides of the excavation, which was 30 ft. by 25 ft. in area, and nearly 30 ft. in depth, previous to the retaining walls being put in. These walls are 6 ft. thick at the base, and diminished by two offsets on the outside to 4 ft. 6 in. and 2 ft. 3 in. respectively. They were built, in all other respects, in a similar manner to the main front retaining wall. It is also rather interesting to note that in several cases the manholes below the basement floor were of such a depth that it became necessary to calculate the walls as retaining walls, and it was found necessary, in some instances, to make them 3 ft. 6 in. thick at the base. These were also executed in plain cement concrete.

A general foundation plan is shown in *Fig.* 7, and the numerous grillages required under the stanchions can be seen; also the positions and length of the retaining walls above described. The figures in the circles are merely the reference numbers for the various stanchions.

Messrs. Trollope Colls & Sons, of Pimlico, were the contractors for this work, while Mr. S. Bylander was the consulting engineer to the architects.

The indented bars were provided by the Patent Indented Steel Bar Co. Ltd., and the Portland cement used was the "Hilton Anderson" brand of the Associated Portland Cement Manufacturers (1900) Ltd.

STANDARD METHODS FOR THE PREPARATION OF REINFORCED CONCRETE DRAWINGS.

By H. KEMPTON DYSON, C.E.
(*Technical Secretary of the Concrete Institute.*)

In view of the great difference which exists among the members of the various professions in the manner of preparing drawings, we think something should be done towards standardising the method for preparing these drawings, which would greatly reduce the expense incurred in the drawing office and be a boon to all concerned. This standardisation would also do away with the necessity of having special drawings made for reproduction in technical journals and trade catalogues. We are glad to note that the Concrete Institute are taking up the matter.—ED.

The advantages of standardisation in all branches of commerce are recognised by everyone nowadays, and there is a general tendency noticeable towards standardisation in many other directions. Theoretically, we may be able to effect economies in the amount of material, and secure a closer approximation towards the true result by variety; but we can, by the judicious choice of fairly extensive lists of standards, economise both time and materials, and, though we may not always secure theoretical efficiency, we are enabled to arrive at a practical result with greater final economy.

Recently, the Concrete Institute has set itself to standardise the symbols employed in making calculations for reinforced concrete designs, and the attention of one of its Committees is now being directed towards the standardisation of drawings for this system of construction. This is only one instance of a tendency, which is to be noticed more especially in the United States, towards some sort of standard methods of preparing working drawings. Though there is some slight variation in detail in the United States in respect to working drawings for steel work, there is a great deal of uniformity to be noted in such drawings as a rule. This standardisation has resulted in a great economy of time in the drawing office and in the works, and the final outcome is that, in many branches of steel work, American practice has resulted in considerable saving over the more elaborate and, perhaps, more theoretical methods which have been customary among English and Continental engineers. Material is often apparently thrown away, but the economy thereby effected of time and labour in other directions more than makes up for the loss. Therefore, we may feel certain that in standardising the methods for the preparation of reinforced concrete drawings, embodying both the preliminary schemes and the final working drawings, a good deal will have been done towards reducing the great amount of expense incurred in the drawing offices of specialists. Another effect, too, which the standardising of drawing methods has had upon structural steel-work practice in the United States will probably be seen in connection with reinforced concrete; that is, in co-ordination and condensation from the chaotic condition of too much individualism in design, and a better understanding of the principles of the subject.

Among the general advantages that may be obtained from having the drawings prepared throughout in a uniform manner are: (1) They become more intelligible to everyone concerned, so securing a better understanding and superior execution.

(2) This standardisation economises in many directions, such as, in saving of time, the avoidance of the necessity for making special drawings for reproduction in catalogues and in the Press, and, indeed, for reproduction by the various processes employed for the copying of drawings, known commonly as blue prints, black-line prints, etc.

To the architect or engineer who has to study the competitive schemes submitted by firms of specialists, drawn up in many ways, and which mostly differ in scale, their examination and comparison is troublesome and wasteful of time, the result often being that some schemes do not receive proper consideration.

Indeed, the advantages of standardisation are as great in respect to the preparation of working drawings as to the manufacture of materials and articles of commerce. It may be doubted whether it is yet opportune to endeavour to standardise systems of reinforced concrete and details of such construction, but it is not too soon to endeavour to standardise the preparation of working drawings for such work. When such is done, we shall have taken some step on the road towards standardising methods of designing reinforced concrete.

Considering the question of drawings for reinforced concrete, we note, firstly, that these belong to two classes of work. In the one case, reinforced concrete is used in works of a civil engineering character, while, on the other hand, it is employed in general building construction. These two branches are in the hands of two professions, namely, that of the Engineer and that of the Architect, each of which differs somewhat in the methods customary at the present date in respect to scales, line-work, and colouring, *i.e.*, methods of recording ideas and specifying requirements. We, therefore, have to decide as to whether it would be advisable, in drawing up standards for draughtsmen, to lean more to one branch than to the other, or whether some middle course should be pursued or a different road taken. The latter would be inadvisable, because it would depart too much from current practice. A middle course is considered the safest, but in this case we are inclined to think that regard should be paid to the amount of work which is to be done in each branch.

Reinforced concrete is most extensively used in building construction at the present date, and it is most probable that it will continue there to be used most largely. In this it is not wished to imply that the largest works, or works costing in the aggregate the most, are executed in this branch of building, but reference is made to the number of jobs which are carried out in which reinforced concrete is employed by architects and by engineers. It seems to be the case that the most drawings are required in connection with the architectural branch of reinforced concrete, and it would therefore seem best if the drawings should conform most closely to the general practice in the architectural profession. The advisability of this can be considered to be strengthened still more by the fact that standards which can be drafted for the preparation of such drawings for architectural work are not useless or unworkable for engineering work. We see that methods which suit the architect are readily legible to the engineer, and will not cause him annoyance nor inconvenience in any way, whereas, if the opposite course were pursued, the architect would find the drawings entirely strange to him and out of character with those for the remainder of the work.

SCALES.

Various specialists and contractors for reinforced concrete work adopt a variety of methods in this country in respect to the scales which they employ in draughting. It would be too great a task to endeavour to standardise scales for drawings for international use, because different nations have different units. This might not be considered as excluding the United States from our purview, but in that country there are also differences of practice and custom; for instance, in the United States they use tons of 2,000 lb. and the writer is not sufficiently familiar with the conditions of American practice to warrant him endeavouring to lay down any standard system to embrace that country; that must be left to American engineers. The writer, however, is inclined to think that the reasons which may lead to certain rules being laid down for this country will be equally applicable to the United States.

A great number of scales are, and have been, employed by architects and engineers in Great Britain, but only a few are generally adopted; we can use these few to fulfil almost all requirements. Fundamentally, we choose a scale to suit the conditions of the extent of the job and the size of the drawing paper, having due regard to clearness. We recognise that a large scale is desirable, but, at the same time, it must not be so large as to be inconvenient in use. We find, therefore, a natural limitation in the number of scales that are practically available, because some scales are too large, others too small. We find that several scales that, theoretically, have been supposed to be advantageous are eliminated from customary use; for instance, a $\frac{1}{10}$-in. scale, which is applicable to decimal equivalents, is too small for general use, and therefore is seldom adopted by architects for jobs of a fair size; it is not unwieldy, indeed, for very large jobs a smaller scale is adopted, the custom being to halve the $\frac{1}{8}$-in. scale and employ a $\frac{1}{16}$-in. scale. The latter is quite too small for showing details of the reinforcement, but on large jobs it would be satisfactory for general schemes such as plans, elevations, and sections, which do not show the reinforcement. The $\frac{1}{8}$-in. scale is still better for such purposes, but both these scales, preferably the latter, become distinctly serviceable in the preparation of sketch-designs and general schemes which are submitted in the preliminary stages of any job, because they conform to the architect's other drawings, and are therefore comparable. Some specialists employ $\frac{1}{8}$-in. scale drawings to show slab reinforcement, and on jobs of any magnitude this is a good system, but the lines are then close together, and in reproduction there may be a tendency for these to obscure one another, such as, for instance, when the rods are spaced as closely as 3 ins. centre to centre. As a rule, however, such a close spacing is not adopted, and the whole area of a floor slab can be lined with reinforcement and yet be clearly interpretable. Where a closer spacing is necessary, it is possible to indicate the general character of the reinforcement on a small portion of the drawing or to put a reference thereon, and provide a detail of a small portion to a larger scale to be read in conjunction therewith.

The $\frac{1}{4}$-in scale is too large for general plans, and is seldom used even for jobs of moderate size. Though it would be suitable for showing the reinforcement of floor slabs, in the same way as above referred to, and, indeed, can be shown much more clearly, it seems, however, to the author, unnecessary because, as a rule, reinforcement of this kind can be shown sufficiently clearly upon $\frac{1}{8}$-in. scale drawings, while the $\frac{1}{4}$-in. scale is not sufficiently large for details in elevation and section.

The $\frac{3}{8}$-in. scale is seldom used, but the $\frac{1}{2}$-in. scale is often employed by specialist engineers for elevations and sections of beams and floor slabs. It is convenient in so far as drawings to this scale do not take up much room, but the $\frac{1}{2}$-in. scale is too small to enable details of the arrangement of the reinforcement to be shown in any but a diagrammatic way. A diagram, however, is all that is necessary in the majority of cases, and economy in the drawing office is effected by its use, for a number of beams can be detailed in a small space which, again, is advantageous on the job, as the foremen and workmen are not hampered with large drawings. Economy is likewise effected in the number of drawings necessary to show the construction being reduced to about half of what would otherwise be necessary. $\frac{1}{2}$-in. scale drawings are, by many specialist engineers, supplemented by sections and details to $1\frac{1}{2}$-in. to 3-in. scales.

The ¾-in. scale does not apparently meet with favour, though it represents one-sixteenth full size.

The 1-in. scale seems to be generally admitted to be a useful scale, and preferable to ¾-in. It is sufficiently large to conveniently show a fair amount of detail and occupies an intermediate position between ½-in. and 1½-in. scales, but the 1-in. scale is often too large for detailed drawings of long beams, and, therefore, though a certain number of engineers have employed the 1-in. scale for their drawings, as all that is necessary can be shown on a ½-in. scale drawing, the writer thinks that, notwithstanding its clearness and serviceability, it is better not to favour it.

The 1½-in. scale is one-eighth full size, and provides sufficient size in which to show details of construction very clearly. It is useful to remember that ⅛ in. to this scale represents 1 in.; so that we can use an ⅛-in. scale to read inches on 1½-in. scale drawings.

The 2-in. scale, so far as the writer is aware, is used only by one firm of reinforced concrete specialists. Though useful for details, it is not a scale which has met with any favour, and it seems to be altogether ignored by architects.

The 3-in. scale is one-quarter full size—a handy ratio—and is very valuable for details of specially intricate work.

Though architects often use half-full size for details, it is generally too large for reinforced concrete work.

We see, therefore, that we may bring a considerable number of scales that are and have been employed in general practice down to a few in reinforced concrete work, these few being quite sufficient to give considerable latitude. They are: The ⅛-in. scale, for general drawings, showing schemes in outline, and for framing plans, showing disposition of beams without reinforcement, and the rods in slabs, both at bottom and top. For the ⅛-in. scale 1/16-in. may be substituted for large jobs, but then it is necessary to show the reinforcements in floor-slabs upon ⅛-in. scale drawings. A ½-in. scale can be used for elevations of beams, etc., and for general diagrammatic drawings. Sections of beams, etc., should be shown to 1½-in. scale. For large details of intricate work the 3-in. scale will be found useful. Thus we have, generally speaking, only three scales in use, namely, the ⅛-in., ½-in., and 1½-in.

It may be well to here emphasise the importance of figuring all dimensions upon the plans, and leaving nothing to be scaled from the drawings.

HOW TO SHOW THE REINFORCEMENTS.

As regards indicating reinforcements upon plans specialists are somewhat at variance. Occasionally we see the bars shown by dotted lines, while the outlines of the beams are shown in full lines, and the walls the same. The more general custom, however, seems to be to employ full lines for the reinforcements, and to dot the beams. This is not quite clear, and it is rather awkward to show walls on the same plans where this method is employed. It is suggested, however, that the best method is to outline the beams by short dots or strokes, and to dot in with long dash strokes the walls. The reinforcements may be shown by heavy lines. On ½-in. scale drawings the main rods may be shown generally by means of thick, solid lines, secondary rods by lines of medium thickness, and the details of the concrete and other work again by means of thin lines. When working with this small scale, it will be found an advantage often to omit the reinforcements in adjoining members, as, for instance, the rods in floor-slabs should be omitted when drawing elevations of **T**-beams, otherwise the main reinforcements may be obscured.

In 1½-in. and 3-in. scale drawings it will generally be found advisable to show rods, when not of too small a size, by means of double lines. These lines, however, should be strongly drawn. As these two latter large scales are generally employed

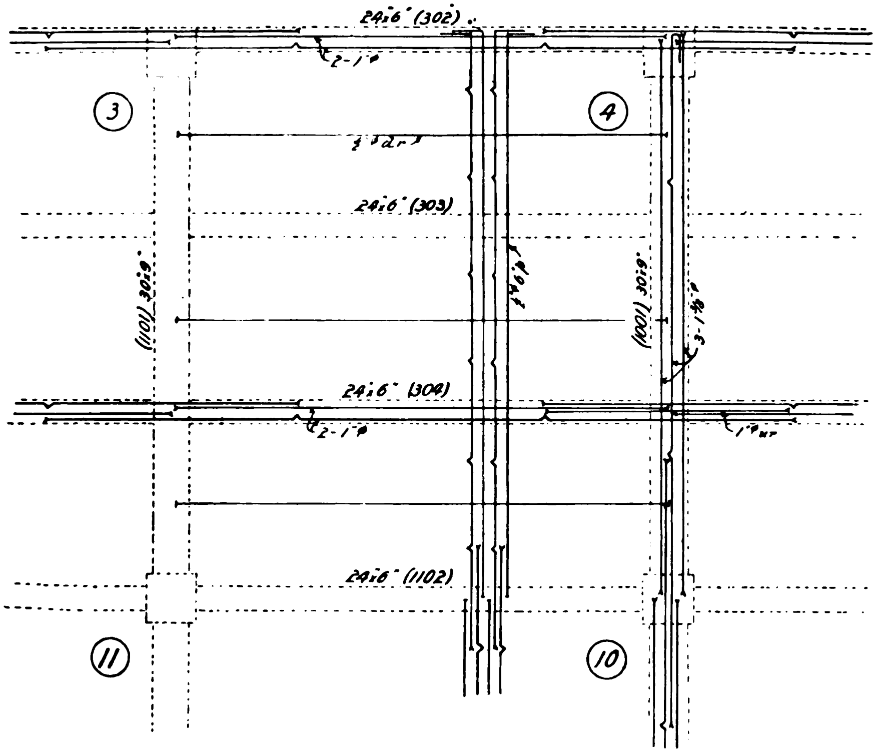


Fig. 1. Plan showing Disposition of Reinforcements in Beams and Slabs.

for sections, it may be here said that it looks well to black-in any reinforcements shown in section. Even on the largest drawings—full size, even—it is better to black-in the sections of steel, for the drawings are made much clearer thereby, and, though emphasis is given to the steel, this is an advantage, as too much emphasis cannot be given to the reinforcements, the drawings being specially intended to indicate them.

If shading of rods is employed, it should not be done on anything less than half-full-size drawings. Sections of beams, etc., will often require picking out, and etching is sometimes employed with this object, but the lines in etching should be very open or, otherwise, if the drawings are reproduced and reduced in size by photographic means (which may very possibly take place, and should always be provided for), any closely-spaced lines will run together or "clog." Many draughtsmen, however, prefer to indicate the concrete by dots, intended to show stones, their contention being that etching takes longer to do and requires great care, for the lines must be spaced with great exactitude at regular distances apart, otherwise the appearance of the drawing is not at all good.

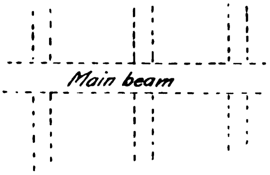


Fig. 2. Showing Outlines of Secondary and Main Beams.

BEAMS AND COLUMNS.

As regards the recording of beams, columns, etc., upon floor plans, it is suggested that the positions of the reinforcements in the columns need not be indicated upon every plan. On the larger plans, where the reinforcements are shown, it is only necessary to indicate the beams and dot in the columns; this omission of the rods in the columns results in making the drawings clearer. On ⅛-in. scale drawings the columns may be blacked in solid. The lines showing the outlines of the secondary beams should abut against the outlines of the main beams, as shown in *Fig.* 2. The columns should be detailed as a complete series throughout the structure, the connections of the same with beams being shown in outline. By this method the reinforcements can be more conveniently shown in their proper relations to each other without them becoming obscured by the lines of the reinforcement in beams. If necessary connections can be shown by 1½-in. and 3-in. details.

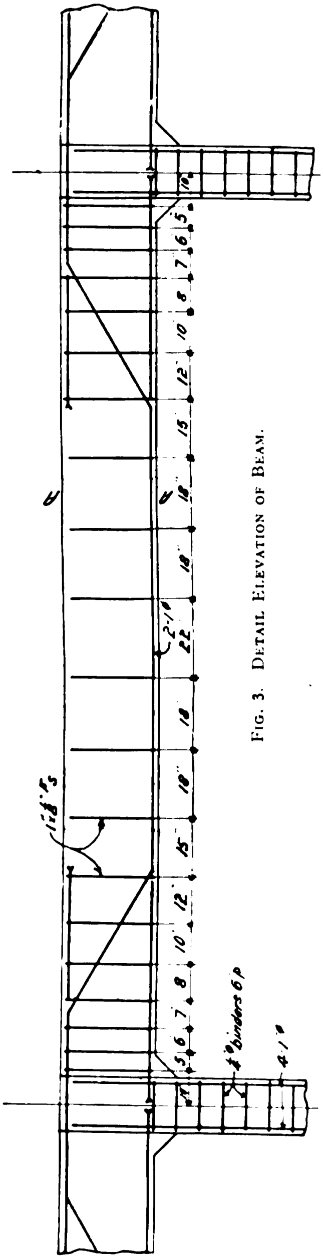


FIG. 3. DETAIL ELEVATION OF BEAM.

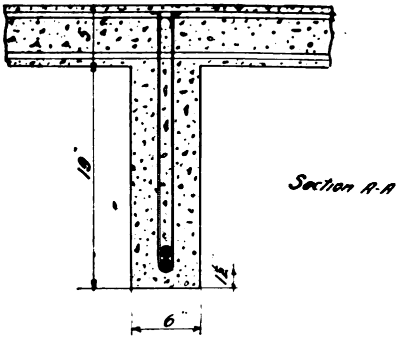


FIG. 4. SECTION OF BEAM IN FIG. 3 TO LARGER SCALE.

INK AND COLOURING.

All drawings for reinforced concrete should be prepared in waterproof black ink, and the lines should be strong and solid. It is of the greatest importance that these requirements should be observed where there is any prospect of the drawings being reproduced in any shape or form at any time. No washes or shading should ever be employed in such cases, because the former come out as solid patches by ordinary methods of reproduction, and the latter, where the drawings are reproduced in process reproduction, tend to clog up and produce solid patches.

It is inadvisable to colour drawings for reinforced concrete; even in drawing details of large size, *i.e.*, 3-in. scale or half-full size, it is inadvisable to dot in the concrete in any way, for if, as may be possible, these details are reproduced in catalogues or the Press at any time, the great reduction that must occur will cause these closely-spaced marks to run together and become clogged, or, perhaps, make a solid patch of ink. It is, of course, possible to reproduce drawings having colour washes upon them, but to do so the half-tone process must be employed, in which there is a screen or meshwork over the surface that breaks up the lines and often renders them indistinct; furthermore, the half-tone process is more expensive than the line process. For superior effect it is most important that all drawings should be done in black and white. Furthermore, this allows of their being copied by the ordinary photo-print process, in which any washes would lead to obscurity of detail. If it be found necessary to employ colours to distinguish various parts of the work, let it be done upon black-line prints, which are easily and cheaply made from drawings; and it may be here mentioned that all colours, except light-blue, by the ordinary photographic method of reproduction, come out the same as though they were in solid black, in which, therefore, if any wash is employed, where reproduction is desired, it must be a very faint blue.

The following list of conventional colours used upon architectural drawings may be found of service where drawings have to be coloured :—

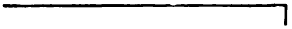
	Section.	Plan and Elevation.
EARTHWORK.	Burnt umber; if turfed, Hooker's green (mixture of Prussian blue and gamboge).	Not coloured.
CONCRETE.	Neutral tint, mottled.	Lighter tint of section colour.
BRICKWORK.	Indian red or crimson lake.	Venetian red or yellow ochre.
	If set in cement, purple and blue.	Lighter tint of section colour.
	If Staffordshire in cement, green.	Ditto.
STONEWORK.	For dressings, sepia; for rough or hard stone, indigo; and for granite, Venetian red or indigo, black dotted with pen.	Lighter tints of section colours.
SLATE.	Green, indigo and yellow; purple, indigo and crimson lake.	Ditto.
TILES.	Venetian red and a little yellow.	Ditto.
PLASTER.	Neutral tint.	Light Prussian blue.
WROUGHT IRON.	Prussian blue.	Lighter tint of section colour.
CAST IRON.	Payne's grey (mixture of indigo, Indian ink and crimson lake).	Ditto.
STEEL.	Purple (mixture of crimson lake and Prussian blue).	Ditto.
LEAD.	Indigo.	Ditto.
BRASS.	Gamboge.	Ditto.
COPPER.	Lake with Venetian red.	Ditto.
GLASS AND GLAZED WORK.	Mottled cobalt.	Ditto.
WOODWORK.	Pine or fir, unwrought and floors, streaked with burnt sienna.	Raw sienna.
	Wrought pine or fir, burnt sienna.	Lighter tint of section colours.
	Oak, sepia and a tinge of yellow.	Ditto.
	Mahogany, brown madder.	Ditto.
	Walnut, sepia and burnt sienna.	Ditto.
CLD WORK.	Black or hatching.	Black or hatching.

It may be here mentioned also, that tracing cloth or linen is very useful for reinforced concrete drawings; instead of it being necessary to prepare pencil drawings, and then perhaps inking them in before tracing, pencilling can be done direct upon the tracing cloth (this permits of ready cleaning, rubbing out or erasing by the simple use of benzine), and upon the same drawings the pencil lines can be inked in for record. Cloth tracings are, of course, stronger, and stand the handling much better than ordinary tracing paper, and do not become so creased as the latter; an item that should be considered, because a mark of this nature on tracing paper and tracing cloth will generally become noticeable in reproducing by the blue-print or black-line process.

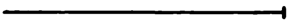
ABBREVIATIONS.

Although we may dimension the lengths of reinforcement on the plan and elevation, it is very advisable to adopt some means of indicating exactly the length of each line by stopping it in some manner, thus, on both ⅛-in. and ½-in. drawings the ends of each line indicating the reinforcement should be terminated by some mark. As the ends of bars and rods are manipulated in practice in various ways it is advisable on any drawings less than 1½-in. scale (upon which, of course, it is possible to draw the exact form the end of the bar takes) to use some sort of shorthand to indicate the various kinds of ends. The writer suggests that the following is an easily understood shorthand, which is clearly, easily, and quickly drawn, and it avoids any necessity for putting wording upon the drawings to state how the ends are to be dealt with :—

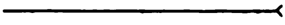
Turned-over ends thus :



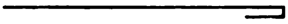
Ordinary cut ends thus :



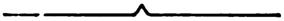
Fishtail ends thus :



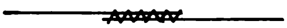
Hooked ends thus :



Cranking thus :



Wired junctions thus :



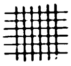
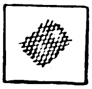
WRITING UPON DRAWINGS.

Much unnecessary time is often spent in preparing drawings for reinforced concrete in writing particulars and descriptions of the work to be done, and the nature of the reinforcements. Not only would some standard list of abbreviations save time to draughtsmen, but the drawings would be clearer and interpretable by everyone consulting them. The following list of abbreviations is one that it is suggested may be employed with advantage :—

Rods (round sections)	**r**
Bars (square and special sections)...	**b**
Wires	**w**
Stirrups	**s**

(Where two forms of stirrups are employed, one consisting of wire and one of flat or hooped steel, it may be advisable to use "w" for the former and "s" for the latter.)

Upper bars or rods	**u b** or **u r**
Cranked bars or rods	**c b** or **c r**
Distributing bars or rods	**d b** or **d r**

Steel Reinforcing Sections	Rounds	Ø
	Squares	□
	Tees	T
	Angles	L
	Joists	I
	Channels	⊔
	Flats or Hoops	F
	Special Bars	Initial letter or letters of trade name.
	Sheet meshes	In sections – – – – – – – – – – On plans  In drawing these meshes on plans they should be shown on part only of each bay, the boundary line of the bay being finely outlined, thus :— 
	Pitch or Spacing (As in columns or slabs)	p
	Feet	′
	Inches	″
	Square Inches	in^2
	Cubic Inches	in^3
	Imperial Wire Gauge	I.W.G.
	British Standard Section	B.S.S.

Examples :—

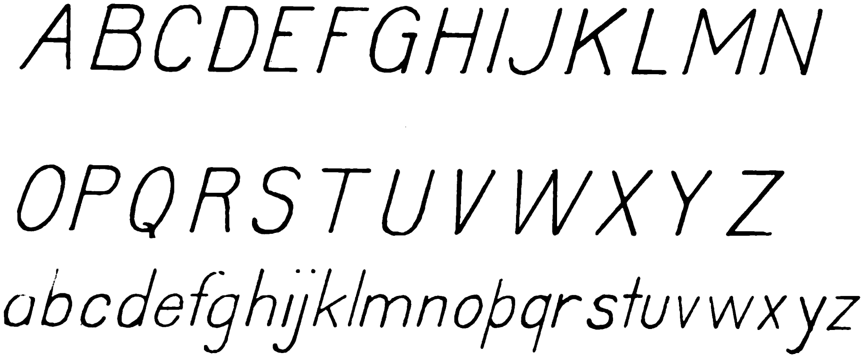
2—1″ □	Two 1-in. square bars.
1″ Ø 3″ p	1-in. round steel rods at 3-in. pitch.
⅛″ × 1″ ^{F}s	1-in. flat stirrup.

LETTERING.

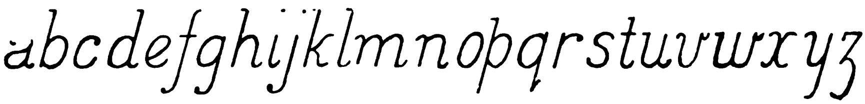
As regards the lettering upon drawings, this should be large and open. Indeed, it cannot be too large. Of course tastes differ in regard to lettering, and in respect to drawings for architectural work of any artistic nature most persons would be averse to making any suggestions, but in respect to reinforced-concrete drawings, these are generally of an engineering character, and clearness is the sole object. The mistake usually made is in keeping the lettering far too small, no thought ever being paid to the drawing being reproduced at some future time. This point is emphasized because there are so many drawings reproduced nowadays, and because one never knows at the commencement of any work what may or may not be reproduced later. There can be no objection to making the lettering as large as it is possible to get in the space. It does not look ugly by being large, and it always tends towards clearness to everybody concerned, while it will in many cases avoid the great expense which formerly it has been often found necessary to incur in the preparation of copies of drawings specially for reproduction.

In American engineering practice, some general standard style of lettering is apparent. Whatever lettering is adopted it should be neat and easily drawn, and the following alphabet is put forward as being likely to meet all requirements. The letters are drawn to minimum size, and can be increased with advantage wherever permissible. It does not really very much matter whether the lettering runs over other parts of the work, though usually by a little manipulation and forethought it is possible to get this large lettering to work in quite well.

Alphabet for ordinary lettering :—



Alphabet in small italics for use in formulæ :—



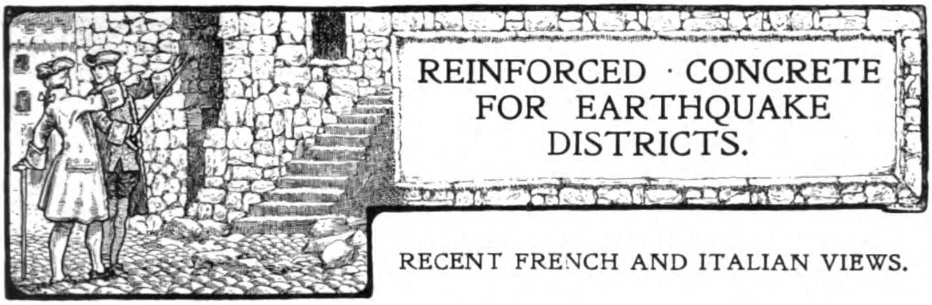
NOTE.—Where capital letters are required in formulæ, Roman letters are employed exactly similar to those shown in the alphabet first recorded above.

EXAMPLES.

In connection with this article some typical general drawings embodying the principles before mentioned, and to serve as examples of the manner in which these can be employed in practice, have been prepared, and are shown in *Figs.* 1, 3, and 4.

In the columns of this Journal drawings prepared by many of the well-known specialists have been reproduced from time to time, and it is not necessary to furnish examples in connection with this article, as this can be done by reference to former issues.

Allied with the subject of the standardisation of drawings is that of classification and tabulation of the designing, quantity taking, and estimating for same. This subject will be dealt with in a succeeding article.



REINFORCED · CONCRETE FOR EARTHQUAKE DISTRICTS.

RECENT FRENCH AND ITALIAN VIEWS.

The subject of safe construction for earthquake districts has become a matter of such importance that we are again devoting space to this question, and present contributions that we believe are of public interest. We are indebted to our Paris contemporary, "Le Béton Armé," for our illustrations. The line drawings on page 97 were kindly lent us by the editor of "Le Ciment," Paris.

MUCH has been published of late regarding the utility of reinforced concrete for buildings in districts subject to earthquakes, and in a previous issue we published an article on this subject from the pen of Dr. von Emperger. From the many other contributions which are appearing, principally in the French, Italian and American papers, we have selected a paper by Monsieur G. Flament Hennebique which we have summarised, and we are also giving extracts from certain Italian papers which were presented on the occasion of a competition organised by the Società Co-operativa Lombarda after the Messina earthquake.

There can be no doubt that monolithic structures of the reinforced concrete type, if suitably designed and well executed, are the most preferable form of building construction at present available for earthquake districts. Buildings of considerable height can be erected with this material in districts subject to severe shock.

A FRENCH CONTRIBUTION TO THE SUBJECT.

AT a recent meeting of the French Society of Civil Engineers a paper was read by Monsieur Flament Hennebique on the resistance of reinforced concrete buildings to earthquake shocks.

The most interesting part of the communication is a report on the behaviour of reinforced concrete structures, stated to have been designed on the Hennebique system. The instances recorded all refer to the great disaster in Southern Italy in December, 1908.

Although many of these structures were in the area subjected to the most violent shocks there was no instance of failure. This is the more noteworthy as the buildings were not specially designed with a view to earthquake resistance.

The structures in question include the following:

1.—Roadway over the Portalegni stream. This remained intact in spite of the débris which accumulated upon it (*Fig.* 9).

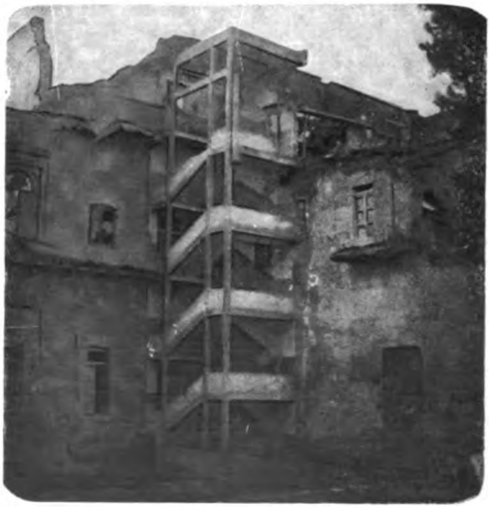


FIG. 1. REINFORCED CONCRETE STAIRCASE, AFTER THE MESSINA EARTHQUAKE.

2.—Floors of the Mandalari Hospital, which resisted and contributed largely to preventing the collapse of the house. It was not found necessary to remove the inmates.

3.—Floors of the Cappellini Hospital, all of which resisted the shock.

4.—Reservoir of 4,000 cub. m. capacity, which remained perfect, and continued to furnish water to the town.

5.—The Messina Museum. The walls having collapsed, the reinforced concrete floors fell with them, but remained unbroken. One floor remained supported by three walls, the fourth having fallen.

6.—Walls and beams of a basin at Gozzi. These fully resisted the shock.

7.—Bridge over the Portalegni. This remained intact (*Fig.* 8).

8.—House adjoining the church of the Madeleine. The reinforced concrete floors remained intact, the church collapsed.

9.—The Natale mill. The building remained intact (*Fig.* 8).

10.—Floor in the electric generating station of the railway. This floor had not suffered in spite of the enormous load it had to support on account of the collapse of the upper parts. The rest of the building, which was in the most severely shaken part of the town, was much cracked.

11.—Waiting-room at the Messina Railway Station. Remained perfectly intact, although the adjoining structure in ordinary masonry was much cracked.

12.—Hospital attached to the Medical School. The building was completely destroyed with the exception of those parts which were in reinforced concrete. The staircase remained standing in the ruins (*Fig.* 1).

13.—Dwelling houses in reinforced concrete remained standing when all the surrounding buildings collapsed. The proprietor and his family in one of these owed their lives to this circumstance, all their neighbours having perished.

M. G. Flament Hennebique's Views. — In designing reinforced-concrete structures for districts subjected to earthquake shocks the aim should be to arrange the structure in such a way as to form a monolithic cage.

The simple rectangular form is quite sufficient under such conditions. There is no need to limit the height of buildings if the base is broad and the upright and horizontal portions firmly united together.

With ordinary buildings the tilting action of the shock causes each wall to pivot about its base, and a wall may be flung off in this way without disturbing the foundations (*Fig.* 4). This is impossible with a reinforced concrete building, which tilts as a whole.

In the Messina earthquake there was very little disturbance of foundations, and M. Hennebique is of opinion that the importance of these is secondary, although reinforced concrete piles, etc., may be necessary in erecting heavy buildings on shifting soil.

Figs. 12 and 14 illustrate the remarkable effect of a moving soil on large reinforced concrete flour-mills in Tunis, the buildings having tilted as a whole without any cracking taking place. Such an accident, although altogether exceptional, indicates the probable behaviour of a reinforced concrete building on loose ground in the event of an earthquake shock.

SOME ITALIAN CONTRIBUTIONS TO THE SUBJECT.

We have referred to the essays which were presented in connection with the Italian competition instituted after the Messina earthquake, the first prize having been obtained by M. Giulio Revere, of Milan, editor of *Il Cemento,* in collaboration with M. Vittorio Gianfranceschi. The following is a summary of the essay which gained this prize, and which was entitled, "For Calabria and Sicily":—

Essay by M. G. Revere and M. V. Gianfranceschi.—The authors prefer a rigid structure, resting freely on the soil, to one which is rigidly connected with the soil by means of heavy foundations. The main foundation may consist of a single plate, only slightly projecting beyond the walls, and this system the authors consider the best when the site is on loose soil, or it may be made up of broad soles beneath each of the walls, cross-connected at intervals. When a hard foundation is only discovered at some depth below the surface, a plate may be constructed at a low level, a frame at the higher level being connected with it, forming a base. Neighbouring houses should be isolated from one another, and cellars should be avoided as far as possible. If the prevailing direction of the shocks be known, the orientation of buildings should be, as far as practicable, such that the waves impinge diagonally, and not normally, on the walls. The plan, proposed by some engineers, of avoiding any rigid connection of the uprights with the base, is to be condemned.

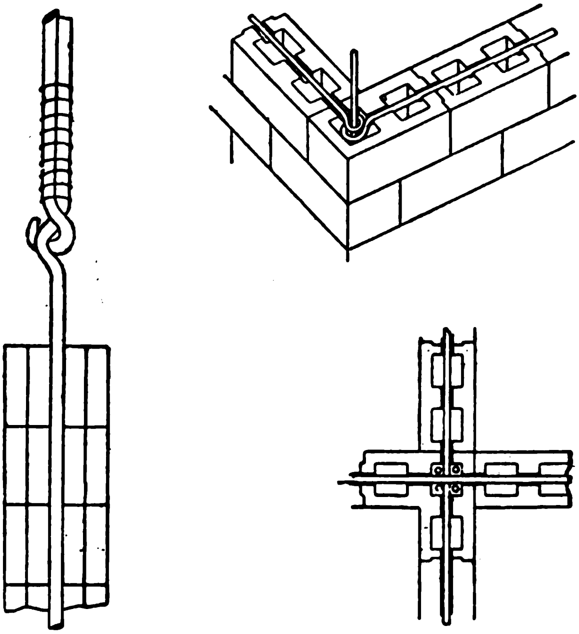


Fig 2. Showing Form of Blocks and Arrangement of Reinforcing Rods.

The necessity of a thoroughly fireproof construction is insisted on, in view of the fact that earthquakes are so frequently followed by extensive conflagrations, and both masonry and steel frame construction are rejected as means of solving the problem. The latter system, so widely adopted, is considered unsuitable for Sicily and Calabria, the districts chiefly considered in the competition. The difficulty of finding skilled smiths is there very great, and this, added to the liability of steel structures to corrosion, and the fact that the most severe stresses are localised in the joints, are serious objections to the adoption of steel.

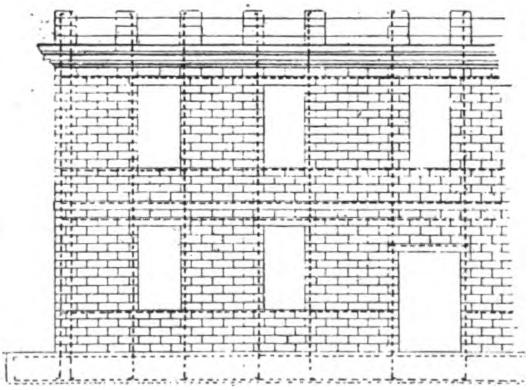


Fig. 3. Showing Arrangement of the Principal Rods in a Building.

The system of construction in reinforced concrete fulfils all the conditions of stability under shock, and of resistance to fire. It has, however, been objected that a high standard of workmanship is indispensable; that a large quantity of wood is necessary for centering and shuttering; and that the system does not lend itself readily to the construction of the double walls, favoured in

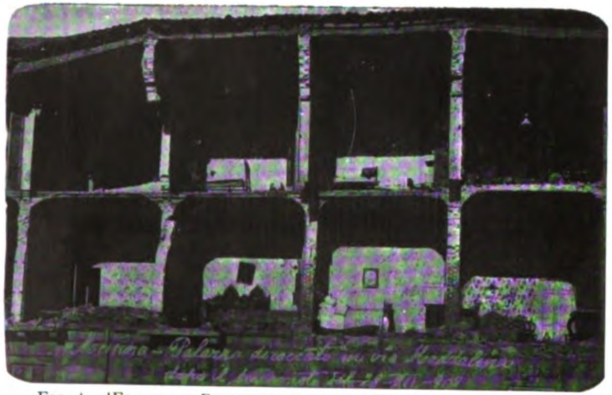


FIG. 4. FRONT OF BUILDING FALLEN. THE DIVISIONAL WALLS AND BEAMS STANDING.

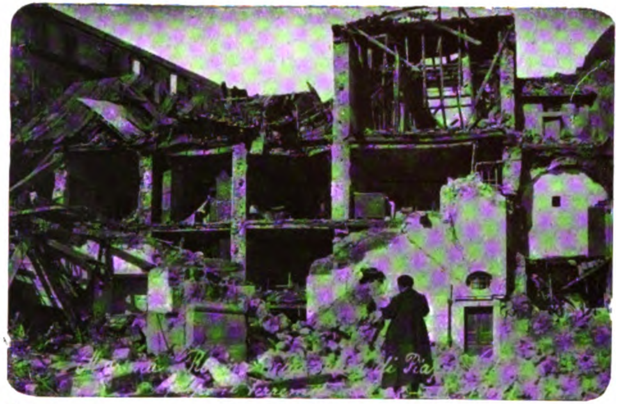


FIG. 5. FRONT AND HORIZONTAL PORTIONS AT UPPER LEVELS FALLEN. THE VERTICAL DIVISIONAL WALLS OF THE STRUCTURE ARE NOT DESTROYED.

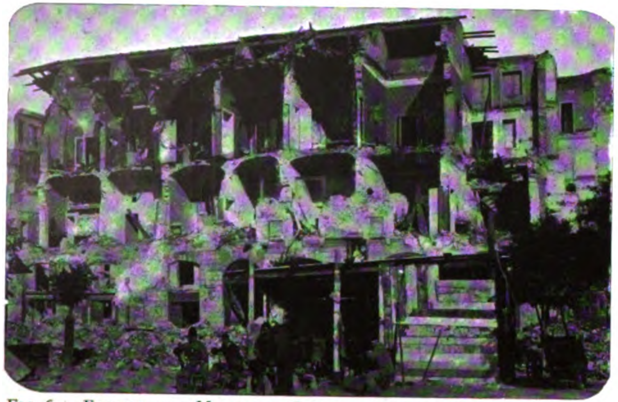


FIG. 6. EFFECT OF A MODERATE SHOCK. FRONT OF BUILDING FALLEN. FURNITURE AND PICTURES WERE NOT DISPLACED.

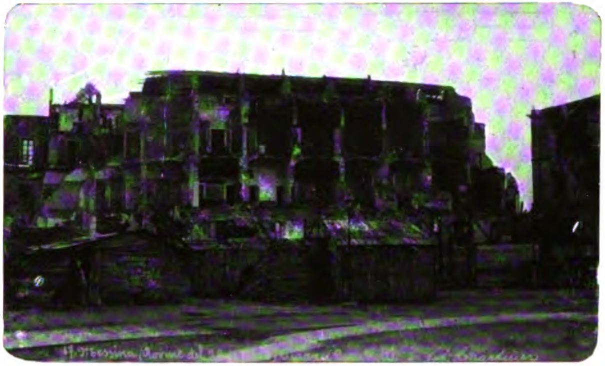


FIG. 7. CHARACTERISTIC WRECKAGE.

[VIEWS TAKEN AFTER THE MESSINA EARTHQUAKE.]

those districts as a means of resisting the hot climate. The authors propose to overcome these difficulties by constructing buildings in hollow concrete blocks with reinforcement.

Hollow blocks, provided with longitudinal grooves for the reception of the reinforcement, are readily manufactured by an ordinary block machine. Round rods are used, all joints being made by crooking the ends and binding with wire. The form of the blocks and the arrangement of the reinforcing rods are seen in *Fig.* 2. The arrangement of the principal rods in a building is seen in *Fig.* 3. Arches and vaults are to be avoided, being replaced by horizontal beams or lintels.

FLOORS.—If the construction of reinforced-concrete floors *in situ* is impracticable, concrete beams, reinforced symmetrically, are to be preferred. Failing them, steel or wood joists, united at intervals by reinforcing rods placed transversely, may be used. The flooring material should be light, and ceilings should be dispensed with as far as possible. Flat roofs, as generally adopted in Southern Italy, are to be recommended.

STAIRCASES.—Stairs should be solidly built in, either between two walls or supported on the inner side by an inclined reinforced-concrete beam, the use of light decking for the stairs being avoided.

The method proposed lends itself to decorative treatment, either by moulding or colouring the external faces of the concrete blocks or by inserting panels of natural stone, care being taken to anchor the latter firmly to the structure. Both dwelling-houses and large buildings may be constructed in this way, with such labour as is usually available in the regions subject to earthquakes.

From the other essays presented on the occasion of the competition we have selected those of Professor Donghi, M. Antonio del Pra and Messrs. E. Vianini & Co., as being representative of Italian ideas on the subject.

Professor Donghi's Views.—The first pamphlet before us is that of the celebrated architect, Professor Daniele Donghi, chief engineer of the Venice municipality. It was published by the Committee Veneto-Trentino, and applies to Calabria and Sicily. The author calls attention to the fact that there is still little known as to the causes of seismic movements. Nevertheless, he foresees that research in this field will at least help to define geographically the zones more or less exposed to earthquakes, and thus enable us to prepare for disaster. To prove this he reproduces what may be termed an earthquake map of Italy.

There are four questions to determine. First, to indicate the location of a seismic zone in which the effects of the moving earth are not extreme; second, to compel the adoption of systems of construction best calculated to resist such movements, *i.e.*, the adoption of indestructible buildings; third, to prepare to give prompt assistance when a disaster happens in the seismic territory; and fourth, to at least convert, if possible, unsafe buildings into safe structures.

After pointing out the necessity for an organisation designed to give prompt aid to victims, such as a disciplined body of men prepared to engage in rescue work at short notice, to protect personal property, and distribute food, medicine, clothing, and disinfectants, all working under supervising authority at Rome, the author comes to the subject of construction, presenting, in part, the following conclusions:—

> The choice of the land should be made based on the following prescriptions already known : avoid the ground having a thin layer of soft material with hard rocky underground, hilly land having an inclined rock formation, isolated hills, the points of discontinuity in land formations, the zone too near seashore, those too rich in minerals or hot springs.
>
> To resist earthquakes buildings should have a monolithic, elastic, and indeformable construction. Avoid constructions of only lumber and those in which lumber is given the function of resistance. Reinforced concrete structures are the safest.

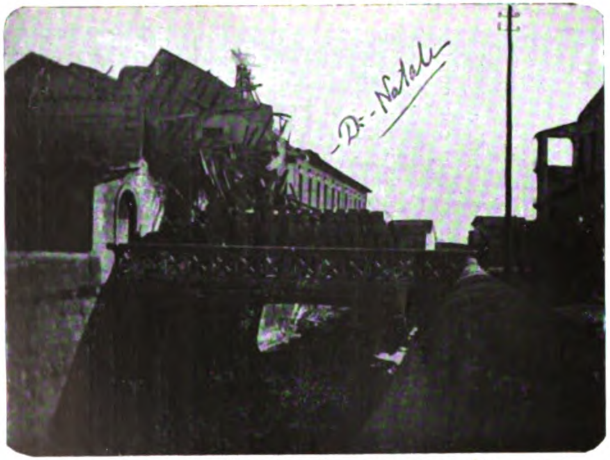


FIG. 8. REINFORCED CONCRETE BRIDGE OVER THE PORTALEGNI, ALSO THE NATALE MILLS.

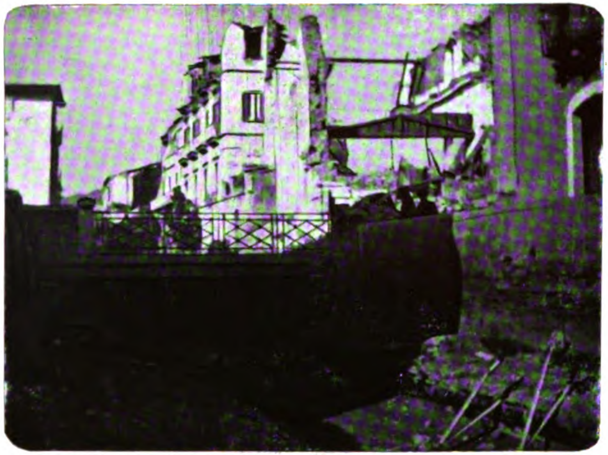


FIG. 9. ANOTHER VIEW OF REINFORCED CONCRETE BRIDGE OVER THE PORTALEGNI RIVER.

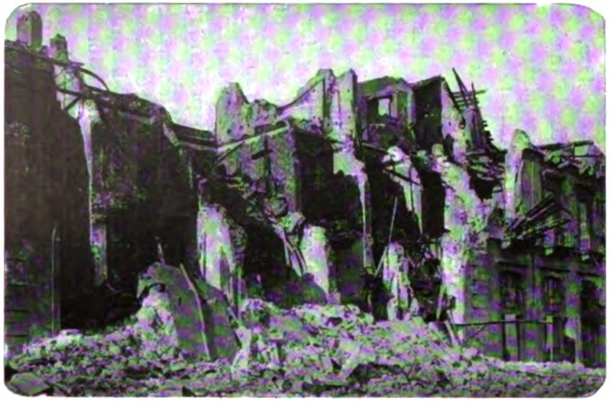


FIG. 10. FRONT PORTIONS AT UPPER LEVELS FALLEN. VERTICAL DIVISIONAL WALLS ARE NOT DISTURBED.

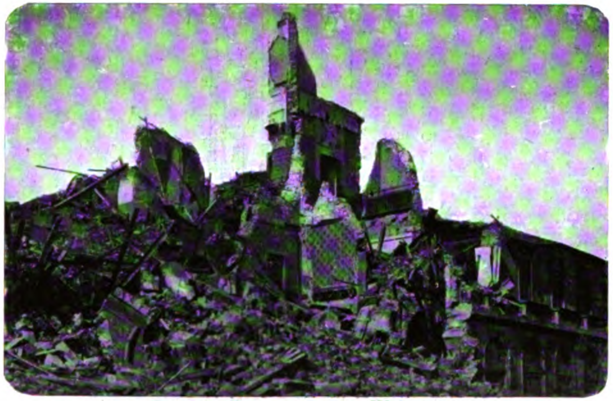


FIG. 11. CHARACTERISTIC WRECKAGE.

[VIEWS TAKEN AFTER THE MESSINA EARTHQUAKE.]

The first problem that we must meet is the determination of the external forces that the building will have to resist from the shocks. The exposure of the house, if possible, should be such that the direction of the strongest shocks will be transmitted diagonally to the building.

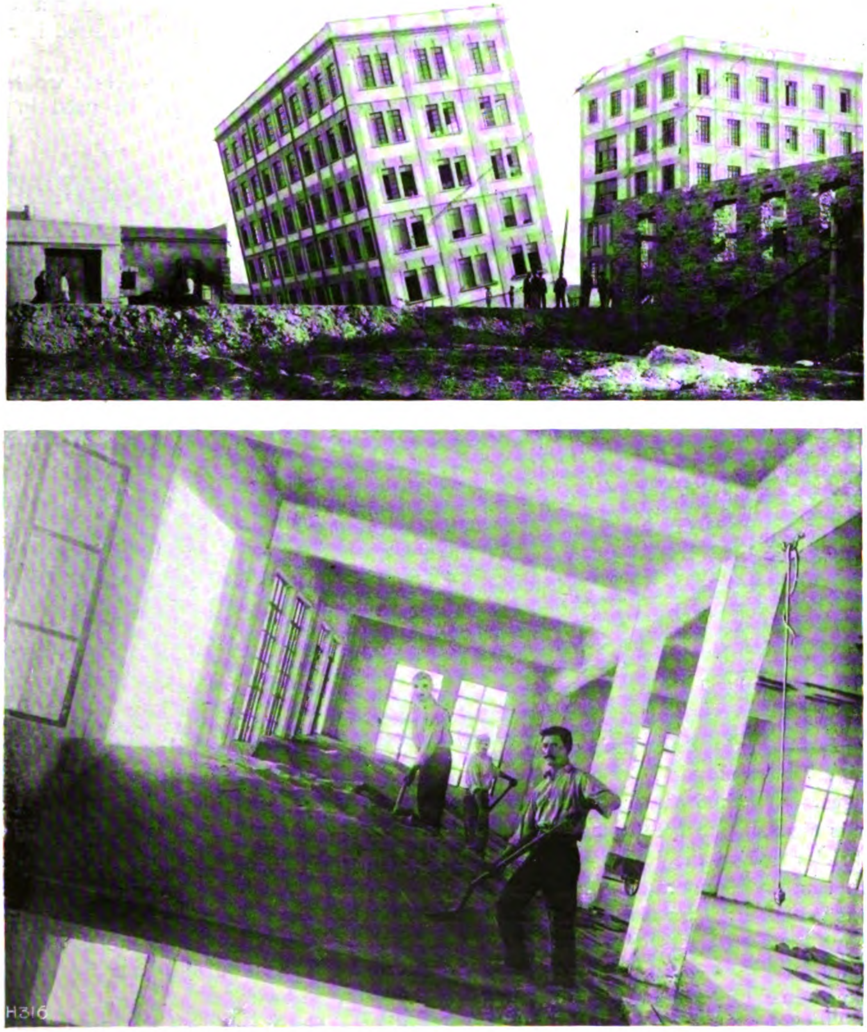


Fig. 12. Exterior and Interior Views of Reinforced Concrete Mills in Tunis. Views after shifting of Soil.

The houses may be separate or attached to each other as well as in straight lines; in the latter case the first and the last buildings should be reinforced with piers to resist the shocks at the extreme points.

The height of the houses should be in proportion to their base.

The foundation should be monolithic and level and should cover the entire ground space of the building; the foundation floor should not be curved, because the length of the seismic waves is very great and the radius of its curves is small.

The walls, according to the author, should be well tied to the foundation and at the same time expansion joints in the side walls should be provided for internal tension and to avoid the sharp vibrations.

The corners of the house near the bottom should also be tied with curved piers to break the stocks, which would be separated and run along the outside platform.

In consideration of its strength and durability the material to be used is reinforced concrete.

The author believes that a skeleton of well-made reinforced concrete would be efficient, and suggests that the ruins of Messina and Reggio be used in the concrete that will be needed.

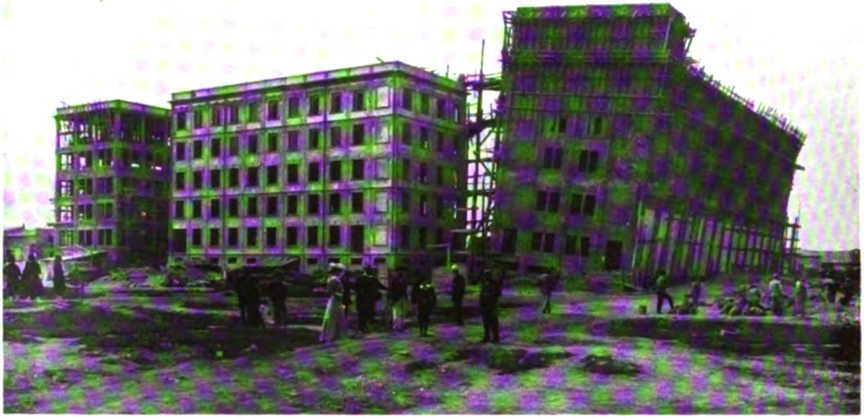


Fig. 13. Reinforced Concrete Mills in Tunis after Shifting of Soil.

M. Antonio del Pra's Views.—Very similar to the Donghi idea is that of the engineer Antonio del Pra. He, too, gives reinforced concrete the preference, but suggests a method of construction with concrete blocks or bricks likely to resist shock if it is necessary to use these materials for economical reasons. He would have blocks or bricks tied at the joints with hooks inserted in the foundation floor, also chained with reinforced-concrete beams inserted in the walls in such a manner as to form spans to the windows and continued for the whole length of the walls. Ceilings should always have two sets of beams, one to support the ordinary loads, the other to do the work only in case of shocks, and reinforced by hooks and diagonals, which will make the ceiling more like a large horizontal reinforced beam.

Thus the walls are made to oscillate together. The resulting construction should be monolithic. Every care should be taken in laying bricks and also in the preparation of the mortar, which should always be enriched with at least a third part cement.

As to reinforced concrete houses, the author is perfectly in accord with Professor Donghi. Given a choice, he would have the ceiling reduced to a skeleton of reinforced concrete with lighter construction, such as timber, for internal ceilings and artificial stone tiling for the roof.

Messrs. E. Vianini's Views.—On a different basis is the plan suggested by the

Soc. E. Vianini & Co., of Rome. This is also a reinforced-concrete type, but introducing novel features by providing for a superstructure whose members will be independent of the concrete floor. To meet and resist undulatory shooks the designers would have the house free to move on its foundation, so to speak. This they believe could be accomplished by building on a smooth reinforced-concrete foundation, considered not only as a sustaining floor, but also as a sliding floor when the violence of the shock surpasses the resistance of the building. Thus the house would be composed of a combination of structural parts of special dimensions laid over each other, but free to move independently.

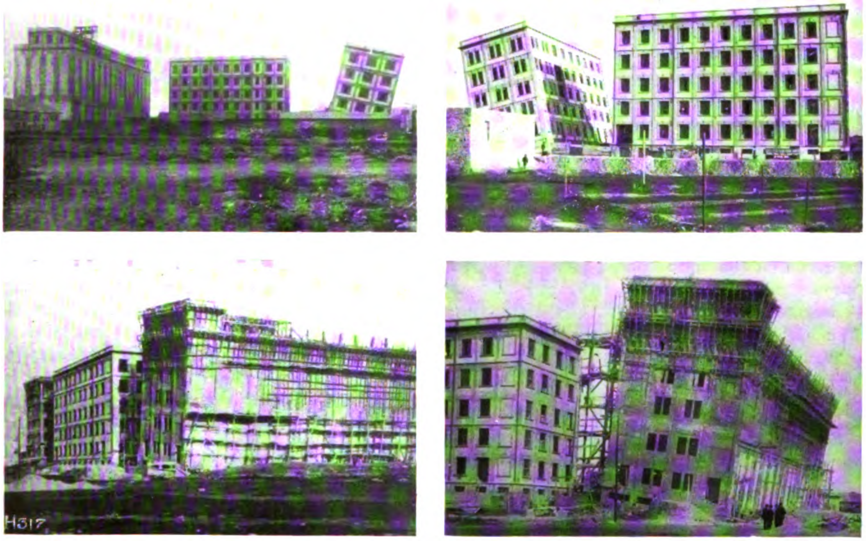


Fig. 14. Reinforced Concrete Buildings in Tunis Tilted by the Shifting of Soil

TESTS ON REINFORCED CONCRETE CONDUCTED IN GREAT BRITAIN.

(PART V.)

The absence of systematic testing relating to reinforced concrete has placed this country at a disadvantage in the utilisation of this modern material for structural purposes. Excepting only in regard to fire tests, such investigations as have been conducted have been quite spasmodic in character, and practically always of a purely private nature.

Having regard to the fact that the question of a series of tests being conducted in this country, in a systematic manner, is having the attention of the Institution of Civil Engineers, the Concrete Institute, and other scientific societies, we are presenting particulars, as far as we are able, in chronological order, of such tests as have been conducted in this country from time to time, and this may serve as a useful guide to those who have the arrangements of the tests of the future.

The first four articles of this series appeared in our May, September, November and January numbers respectively. The following particulars of tests are now presented, and further articles will appear from time to time.—ED.

INDENTED STEEL BAR TESTS.

Fig. 25 shows the detailed construction of a floor at the Waldorf Hotel, London, reinforced with "indented steel bars," one panel of which was tested in January, 1907. The floor was that of a private dining-room on the main floor, and was designed to carry a safe load of 2 cwt. per sq. ft. The panel was supported on main girders 10 ft. 10¾ in. centre to centre, the length of the panel being 26 ft. 11 in. The concrete slab was 5½ in. thick, the concrete being made 1 part Portland cement, 3 parts broken brick, 2 parts sand, and 2 parts coke breeze, the aggregate being crushed to a size of about 1 in. The concrete was all mixed in a Smith mixer. The reinforcement consisted of ½ in. indented bars placed 5½ in. apart centre to centre, with four cross bars in the panel at a spacing of about 2 ft. apart. The test load was applied by means of bags of cement placed in layers on the floor, the final load being 4 cwt. per sq. ft., or twice the calculated safe load. The deflections were as follows :—

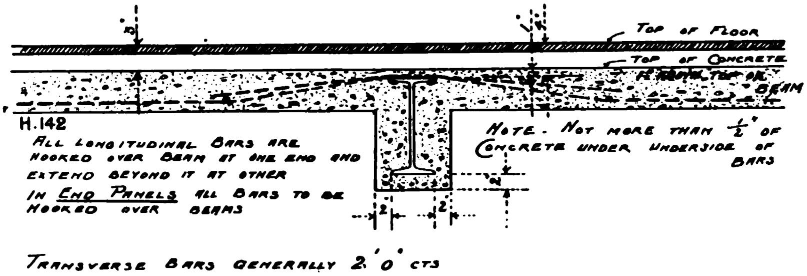

Top of Floor
Top of Concrete
Beam
H.142
All Longitudinal Bars are Hooked over Beam at one end and extend beyond it at other
In End Panels all Bars to be Hooked over Beams
Note. Not more than ½" of Concrete under Underside of Bars
2
2
Transverse Bars generally 2' 0" cts

FIG. 25. CONSTRUCTION OF FLOOR AT WALDORF HOTEL TESTED IN 1907.

Load. Cwts. per sq. ft.	Deflection of Concrete Slab. Inches.	Deflection of Main Steel Girders. Inches.
½	1/16	—
1	⅛	—
1½	3/16	1/16
2	5/16	⅛
2½	7/16	3/16
3	7/16	⅜
3½	⅝	7/16
4	13/16	9/16

On the load being removed, the permanent set due to deflection of both girders and concrete proved to be ⅛ in. No cracks on the underside were noticed. The test was conducted by the architects, Messrs. Archibald Mackenzie & Son.

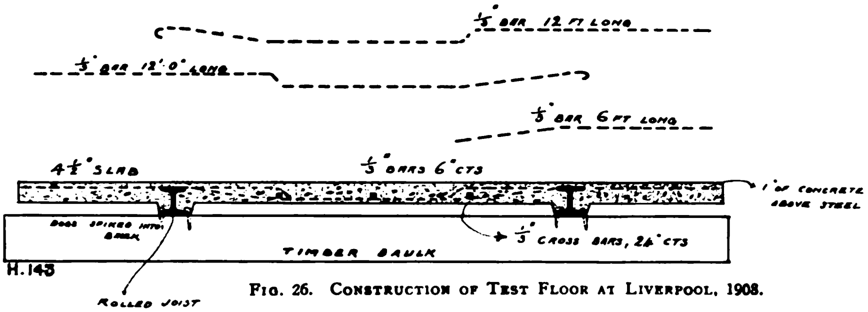


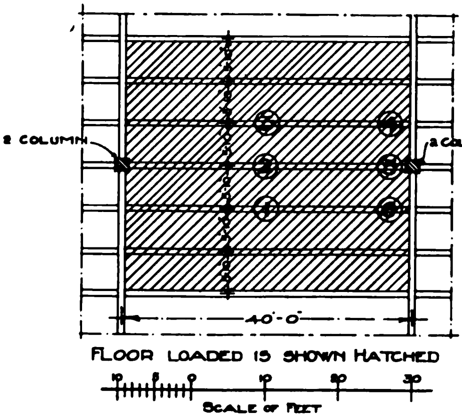
Fig. 26. Construction of Test Floor at Liverpool, 1908.

Fig. 26 shows another test, in April, 1908, of a floor at Liverpool reinforced with indented bars A wet gauging of concrete was used in the following proportions : 3 parts clinker, 2 parts gravel, 1 part crushed brick, and 1 part Portland cement. The test slab was made February 28th, and tested on April 4th. The thickness of the slab was 4½ in. The following were the deflections recorded at various stages of the loading :—

Time.	Apr. 14, 1908	Apr. 14, 1908	Apr. 14, 1908	Apr. 14, 1908	After 48 hours	Apr. 22, 1908	Apr. 22, 1908	Apr. 22, 1908	Apr. 22, 1908	Apr. 22, 1908
Load, total	—	162 cwt. 4 lb.	102 cwt. 2 lb.	133 cwt. 3 lb.	—	Release	None	—	Sand 15" deep	Sand 2' 6" deep
Load per sq. ft.	½ cwt.	86 lb.	140 lb.	207 lb.	—	—	—	¾ cwt.	—	—
Deflection at E, inches	$\frac{3}{64}$	$\frac{5}{64}$	$\frac{12}{64}$	$\frac{14.5}{64}$	$\frac{20}{64}$	$\frac{15}{64}$	$\frac{11}{64}$	$\frac{17}{64}$	$\frac{20}{64}$	$\frac{22}{64}$

HENNEBIQUE TESTS.

A portion of the floor of the new Sorting Office at the General Post Office, St. Martin's-le-Grand, London, constructed of reinforced concrete on the Hennebique system, was tested on September 23rd, 1908. The portion tested was a complete bay with the superficial area of 40 ft. by 35 ft., or 1,400 sq. ft., as shown by *Fig.* 27. The bay consisted of six secondary beams 8 in. wide by 18 in. deep, excluding the floor slab, which is 3½ in. thick. The beams are spaced 5 ft. 10 in. apart at centres, and have a span of 40 ft. between the centres of the supporting beams and columns. The secondary beams are reinforced by four 1¼ in. dia. tension bars, two ¾-in. dia. compression bars, and numerous stirrups for resisting diagonal tension or shearing stresses. The floor slab is reinforced by ⅜-in. dia. tension bars running in two directions at right angles to one another, as well as by stirrups like those in the beams. The arrangement of the bars in both elements of the construction is that always adopted in the



1.2.3.4.5.6. SHOW POSITIONS OF DEFLECTION MEASURING INSTRUMENTS

LOADS	·READING ON INSTRUMENTS·						REMARKS
	①	②	③	④	⑤	⑥	
LOADING NIL	0	0	0	0	0	0	23 · 9 · 06
Dº 1CWT.	15/64	15/64	12/64	1/64	0	1/64	
Dº 1½CWT.	22/64	20/64	20/64	2/64	0	2/64	
UNLOADING 1CWT.	19/64	17/64	16/64	1/64	0	2/64	READINGS TAKEN · 9-30PM · 23 · 9 · 08
Dº 1CWT.	17/64	16/64	16/64	2/64	0	2/64	READINGS TAKEN · 6-30AM · 24 · 9 · 08
Dº NIL	3/64	0	0	0	0	0	READINGS TAKEN · 10 AM · 25 · 9 · 08

H.141

Fig. 27. Load on Hennebique Floor at New Sorting Office at G.P.O., London.

Hennebique system, and now so generally familiar. The concrete was made in the proportions of 6 cwt. Portland cement, 13½ cu. ft. clean sharp sand, and 27 cu. ft. washed gravel crushed to pass through a ¾-in dia. gauge. The floor was designed for a working super load of 1 cwt. per sq. ft.

The first test consisted in spreading the load of 70 tons, or 1 cwt. per sq. ft., over the area selected, deflection being measured at the centre of the three supporting beams by delicate instruments graduated in 64ths of an inch. Loading was started at 9 a.m. on September 23rd, after the instruments had been adjusted in position below the centre of the beams, and other instruments at the ends to measure the downward movement of the supports. Under the normal load of 1 cwt. per sq. ft. the following results were obtained :—

Beam No.	Deflection Total	 At Support	 Nett	Proportion of Span
1	$\frac{15}{64}$	$\frac{1}{64}$	$\frac{14}{64}$	1·2140
2	$\frac{13}{64}$	—	$\frac{13}{64}$	1·2300
3	$\frac{12}{64}$	$\frac{1}{64}$	$\frac{11}{64}$	1·2730

Under the full test load of 1½ cwt. per sq. ft. the results were :—

Beam No.	Deflection Total	 At Support	 Nett	Proportion of Span
1	$\frac{22}{64}$	$\frac{2}{64}$	$\frac{20}{64}$	1·1500
2	$\frac{20}{64}$	—	$\frac{20}{64}$	1·1500
3	$\frac{20}{64}$	$\frac{2}{64}$	$\frac{18}{64}$	1·1670

The extra loading was removed by 9 p.m., when all the beams immediately rose to the extent of about $\frac{3}{64}$ in. at the centre of the span, readings taken at 6.30 a.m. and 9 a.m. on September 24th showing that no perceptible alteration had taken place in the form of the beams during the 12 hours following the removal of the extra loading.

At 11 a.m. on September 24th removal of the normal load was started. By 5 p.m., when one-third of the load had been taken away, the average rise of the beams was rather more than $\frac{3}{64}$.

On September 25th at 8.30 a.m., when half the normal load had been removed, the beams rose to the extent of $\frac{3}{64}$ in. at the centre, and at 10.45 a.m., when the floor was quite cleared, the instruments showed that the construction had quite regained its original form.

KLEINE TESTS.

Below we give particulars of tests on "Kleine" patent reinforced hollow-brick and concrete floors, full details of which are given in the illustrations and the description.

Careful precautions were taken to ensure the load being truly distributed on the slabs. In particular, we may instance the London test in which, we believe, the arrangement of applying the load was similar to that at Charlottenburg.

We also call attention to the fact that all the tests were made on freely supported slabs. Of course, when floors are built into iron girders by the "Kleine" patent fire-resisting flooring, the design of the floor is altered slightly so that the resistance in section of the floor would be different for the same spans, as in the particular cases of the tests noted.

In the test carried out at Messrs. Higgins' brickfields at Cheetham, Manchester, the floor was constructed as follows: Hollow bricks, 10 in. by 6 in. by 4 in., with a central web, and an average thickness of material of 1 in. were laid on centering in eleven longitudinal rows, alternately on edge and on flat, and breaking joint. The vertical joint between courses averaged ⅜ in. thick. Embedded in each $\frac{5}{16}$ in. above the soffit was a strip of hoop iron 2 in. by 0·17 in. running the full length of the joint. Above the bricks, and bonded to them by the alternate brick courses on edge, was a layer of concrete alternately 5⅜ in. and 7⅜ in. in depth, bringing the total depth of the floor up to 11⅜ in.

The vertical joints between bricks were made of cement mortar composed of 1 cement to 3 of sand. The bonding referred to above, produced by laying the bricks alternately on edge and on flat, was for the purpose of preventing thrust and shearing.

The floor had no side support, and rested freely at each end on a 5 in. by 2¼ in. iron rail, with a clear span of 12 ft. The weight was borne by the rounded upper surface of rail 2¼ in. wide. Each rail was bedded in cement on a 13½ in. brick wall, 2 ft. 9 in. high. The width of the floor was 5 ft. 3 in.

At each side of the centre slab was a strip of flooring 16 in. wide, continuous to, but quite independent of, the centre slab; the intention being to show that the centre slab would deflect without in any way affecting the side strips, which proved to be the case.

The floor was designed to carry a safe working load of 2 cwt. per sq. ft., with a factor of safety of 4; giving a breaking load of 8 cwt. per sq. ft. (The actual breaking load exceeded this amount, as shown.)

In loading for the test a space 6 in. wide was left uncovered at each end of the span. The remaining space of 11 ft. by 5 ft. 3 in. or 57¾ sq. ft. was covered with an evenly distributed load of common bricks, 12 of which weighed 113 lb. The weights per sq. ft. refer to this area of 57¾ sq. ft.

To avoid any reduction of pressure through the bricks forming an arch across the span, they were piled up in six 18-in. walls, and one 12-in. wall across the floor, with a clear space between walls of 1 in. In the twelfth course and upwards, this space was increased to 3 in. by reducing the thickness of walls.

The illustration (*Fig.* 28) shows how the measurements were taken. Under the floor, at the centre of its length, were three upright posts, to which were fixed carefully drawn scales. Stout hoop irons fixed to the soffit of floor pressed lightly against these scales, and enabled the deflection to be read to 100th of an inch.

At each end of the floor a stout post fixed into the ground and a rod projecting from the lower part of the floor enabled similar readings to be taken of any slight outward thrust due to the deflection.

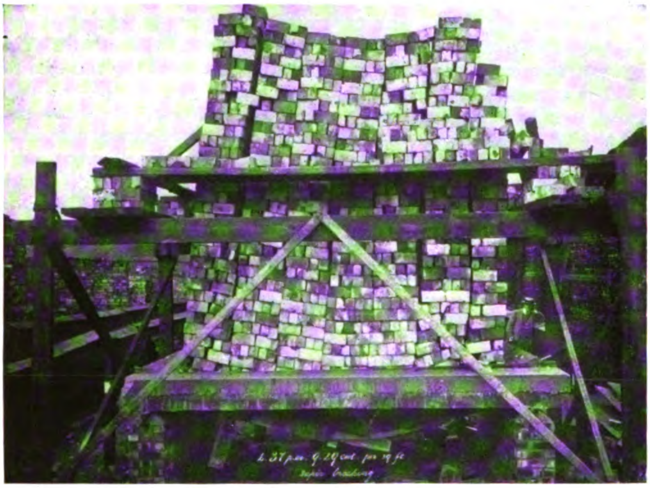


FIG. 28. TEST AT MANCHESTER.

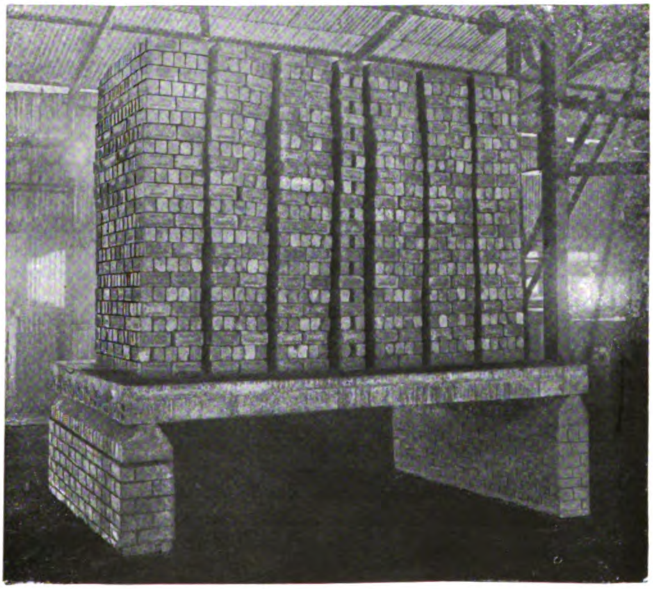


Fig. 29. TEST ON KLEINE FLOOR AT MESSRS. BLADEN & CO.'S WORKS, GLASGOW, DECEMBER 6, 1907.

A test was conducted by Mr. R. D. Sandilands, architect, at the works of Messrs. Bladen & Co., Parkhead, Glasgow, on December 6th, 1907, on a floor constructed on the Kleine system. This was composed of hollow bricks, 10 in. by 6½ in. by 4½ in., the thickness of the material including the central web was ⅞ in., the bricks were laid on centering in longitudinal rows, the joints between each row being ⅜ in. wide, with an iron strip 1⅞ in. by 0·118 in. going from end to end of longitudinal joints. The bricks were laid alternately on edge and on flat, and the whole surface covered over with concrete to a depth of 3½ in. over bricks on edge, and 5½ in. over bricks on flat, the total thickness of floor being 10 in. The composition of cement mortar was in the proportion of 1 to 3, and the concrete 1 to 5.

The floor was supported at each end on beams 5 in. by 4½ in. filled with cement, and resting on 14-in. brick walls built in cement, and about 3 ft. high: the distance between the beams gave a span of 12 ft.

The width of the floor was 5 ft. 4 in., and at each side there was a strip of flooring 1 ft. 5 in. wide, but disconnected from the main portion of the floor by a strip of felt the full depth of the floor, and as the load was put on and the floor deflected, the sides remained as at first, and were in no way affected by the movement.

The floor was constructed to carry a safe load of 1½ cwt. per sq. ft., with a factor of safety of 4, thus giving a breaking load of 6 cwt. per sq. ft. This was exceeded.

The floor was loaded with bricks up to within 3 in. of rest at ends, and to within 5 in. of joint at sides. The bricks were built in seven walls across the floor with a clear space of about 3 in. between each wall to prevent the bricks from coming together at top and thus forming an arch across the span.

The area loaded—4 ft. 7 in. by 11 ft. 6 in. = 52·3 sq. ft.—was covered with a distributed load of bricks, 10 of which weighed 84 lbs. The illustration will show how the bricks were placed on the floor, and also the position of the scales by which the deflection was arrived at.

The deflection was not noticeable until a load of nearly 2 cwt. per sq. ft. had been built up, after which the deflection was gradual until a load of 5½ cwt. per sq. ft. had been reached, when it was seen that the floor was leaving the strips of flooring at sides. The loading was continued until a weight of 6·38 cwt. per sq. ft. was reached, when it was found that the deflection was equal to 0·4. The floor was then left standing, and on examination 14 days later it was found that the deflection had only increased to 0·6. It was still standing under load on May 7th, 1908.

BLACKADDER'S TESTS, 1906.

Some tests were conducted in 1904 by Mr. William Blackadder, B.Sc., C.E., of Glasgow, when he was in the Harbour Engineer's Office at Aberdeen. In these tests the usual method of loading the beams directly with bars of cast iron was not employed, Mr. Blackadder feeling that this was not an accurate enough method owing to the interlocking of the cast-iron bars used. He had not a testing machine available of the ordinary character, so he constructed one made entirely out of old timber used in temporary works round the harbour, and the loading was done with cast-iron bars from the same source. It was really a compact lever, its action being similar to the ordinary "nutcracker." It consisted of a lever of two pitch-pine piles 12 in. by 12 in. and 22 ft. long, bolted together just as taken out of a cofferdam, held at one end by a chain to the lower beams, and loaded at the long end by the cast-iron bars. By prolonging the beams to beyond the end of the lever there could be no overturning of the machine about either end. A represents a beam to be tested (*Fig.* 30), and the way in which the load is transferred to the beam at points (*aa*) through the transfer beam T is clearly shown. Considerable accuracy was obtained with this machine. The lever was weighed and balanced to find the exact centre of gravity. The chain had shackles on each side to admit of adjustment so as to keep the lever "floating" level. Under the lever was put a rocker made of jarrah wood to allow free motion of the lever and prevent load being transferred to one end of the test beam if lever were out of the horizontal; and a similar rocker was put under the first to keep the load central on the transfer beam in case of any tendency of the lever to rock sideways. The transfer beam loaded the test beam at two points (*aa*) equidistant from the centre of the span. On these load points on the test beam were put rockers (*R*4 on drawing) of ¾-in steel plates and 2-in. round bar freely allowing for deflection of test beam. Similar rockers (*R*3) were placed at the supported ends of the test beams to allow the ends to cant freely when deflection took place. Measurements of the lever arm of machine and position of cast-iron bars, which were previously weighed, were taken, and so knowing the span and position of the load points (*aa*) the actual bending moment applied was very closely obtainable. The test beams were 8 in. by 8 in. by 7 ft. 6 in. (6 ft. 8 in. span), composed of concrete 1 cement 2 sand, 3½ of ½-in. to ¾-in. granite reinforced from ·52 to 1·43 per cent. (some with inclined shear members, consisting of ⅜ in. rods slipped over the lower rods as shown in *Fig.* 31). Expanded metal and concrete slabs were also broken with the machine. These had expanded metal No. 8 in the lower side and were 3 in. thick. These were loaded centrally.

The following table gives the particulars of the experiments conducted on slabs reinforced with expanded metal :—

TABLE I.

	Value of $m=\frac{M}{bd^2}$	
	Experiment	Average of Experiment
·46 per cent.	232, 303, 303 (376)	279
·70 ,, ,, ...	310, 362, 380	340
·76 ,, ,, ...	327, 334, 334, 350 (408)	336

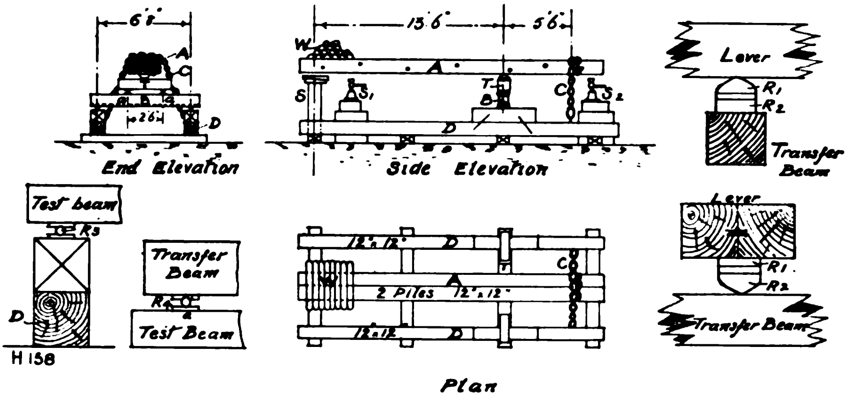


FIG. 30. METHOD OF CONDUCTING MR. WILLIAM BLACKADDER'S TESTS.

The results in parentheses have been neglected in calculating the averages, as Mr. Blackadder thought such high values open to suspicion, the load perhaps not being freely distributed over the slab. The results of the tests on the beams are shown in Table II.

TABLE II.

Diam. of Rods.	Percentage of Reinforcement.	Breaking Load (Tons)	Remarks.
⅜"	·518	3·45 3·25	No shear reinforcement. Do.
½"	·923	3·95 4·40 4·77	Do. Do. Shear reinforcement.
⅝"	1·43	5·50 5·90	No shear reinforcement. Shear reinforcement.

In his investigations, Mr. Blackadder adopted the value of 2,140 lbs. per sq. in. as the compressive strength of the concrete, and 170 lbs. per sq. in. as the tensile strength.

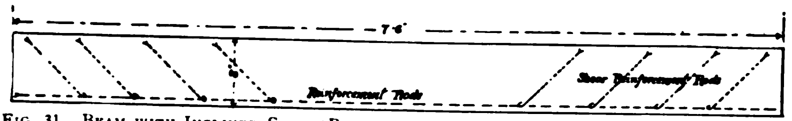
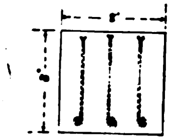


FIG. 31. BEAM WITH INCLINED SHEAR REINFORCEMENT TESTED BY MR. WILLIAM BLACKADDER.



SECTION OF BEAM SHOWING ARRANGEMENT OF SHEAR MEMBERS.

TESTS FOR MR. A. E. WILLIAMS.

Some tests on reinforced concrete beams were conducted in October and December, 1902, by Messrs. David Kirkaldy & Son for Mr. A. E. Williams, of Dagenham Dock, Essex. The form of these beams is shown in *Figs.* 32 and 33.

These beams had relation to Mr. Williams's patented system of reinforced concrete construction which is worked by Messrs. Samuel Williams & Sons, Ltd.

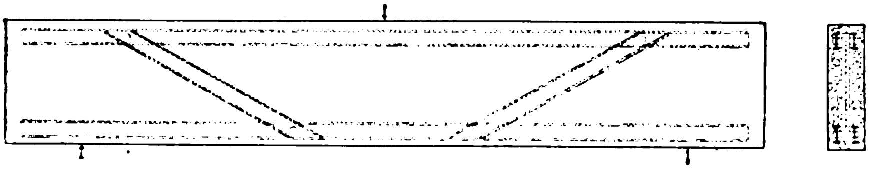
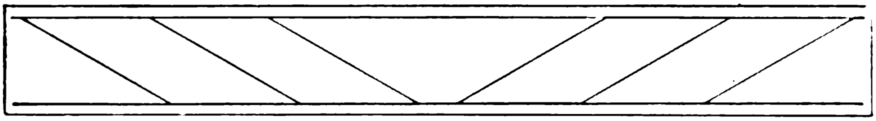
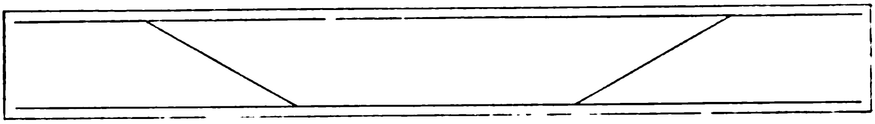


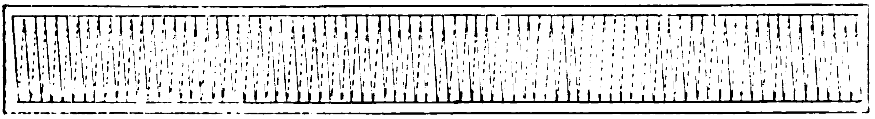
FIG. 32. BEAM OF TYPE KK 4264 TESTED FOR MR. A. E. WILLIAMS.



Another Beam of Type KK 4264.



Beam of Type KK 4264.



Beam of Type KK 3140, 3141, 3142.

FIG. 33. BEAMS TESTED FOR MR. A. E. WILLIAMS.

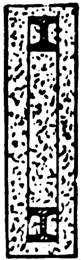
The tables on page 111 are copies of those included in Messrs. Kirkaldy & Son's report.

The load in each case was centrally applied over a bearing of 15 in. long.

We also give in connection with same the results of tests on cubes of concrete so as to provide data of its strength.

RESULTS OF EXPERIMENTS TO ASCERTAIN THE RESISTANCE TO THRUSTING STRESS OF THREE 6-IN. CUBES OF CONCRETE.

Test No.	Description	Dimensions		Base Area	Cracked Slightly			Crushed		
					Stress	Per sq. in.	Per sq. ft.	Stress	Per sq. in.	Per sq. ft.
		in.		sq. in.	lb.	lb.	tons	lb.	lb.	tons
KK	Made from same mixing of Concrete as KK									
3143	Marked 1. Beam 3140 KK	6·00	6·00 × 6·00	36·00	70,800	1,967	126·5 } 116·3	70,800	1,967	126·5 } 128·2
3144	Marked 2. Beam 3141 KK	6·00	6·00 × 6·00	36·00	59,400	1,650	106·1	72,810	2,022	130·0
3145	Not marked. Beam 3142	6·05	6·04 × 6·00	36·24	48,900	1,349	86·8	81,720	2,255	145·0

Test No.	Description	Dimensions	Span	Stress in Pounds, Deflection and Set, inch, at 20,000	25,000	30,000	35,000	40,000	45,000	50,000	55,000	60,000	65,000	70,000	75,000	80,000	85,000	Ultimate Stress		Remarks
		in.	ft.															lb.	lb. tons	
KK	3″ × 3″ joists lapped with wire, 20 dia. wound spirally about 3″ pitch Section	B. D.																		
3140	 Marked Aug. 25th, 1902	7·2 × 24·2	10	·020 set	·030	·040	·054	·073	·092	·113 ·018	·138	·160 ·030	·192	·227 ·066	·274	—	—	79·950	81,220 36·3	Yielding and cracking about 54,000 lb.
3141	Marked Aug. 28th, 1902	7·1 × 24·5	10	·030 set	·043	·057	·072	·086	·102	·122 ·018	·146	·170 ·026	·199	·220 ·034	·250	·287 ·074	—	82,490		Yielding and cracking about 67,000 lb.
3142	Marked Sept. 6th, 1902	7·1 × 24·5	10	·030 set	·044	·060	·077	·097 ·024	·117	·139 ·033	·164	·190 ·046	·230	·48	—	—	—		70,090 31·3	Yielding and cracking about 55,000 lb.

Tested Oct. 23rd, 1902. Initial Stress 10,000 lb.

Test No.	Description	Dimensions	Span	Stress in Pounds, Deflection and Set, inch, at 20,000	25,000	30,000	35,000	40,000	45,000	50,000	55,000	60,000	65,000	70,000	75,000	80,000	Ultimate Stress		Remarks
		In. B. D.	Ft.														lb.	lb. tons	
KK	Concrete composed of 2 parts ¾ shingle, 1 part sand, ¼ and three bags of cement to the yard																		
4264	Marked Nov. 3, 1902. Four rolled steel joists, 3″ × 1⅝″, and two bracing joists, as sketched	7·4 × 24·7	10	·020 set	·030	·040	·050	·064	·084	·106	·130	·168	·222	·347 ·174	·580	—	82·940	87·170 38·9	Fine crack at 60,000 lb. Well cracked at 79,500 lb.
4265	Marked Nov. 3, 1902. Four rolled steel joists, 3″ × 1⅝″, and two bracing joists (as sketched), all lapped with wire 20″ dia. wound spirally about 3″ pitch	7·2 × 24·7	10	·020 set	·031	·043	·056	·069	·083	·098	·113	·127	·150	·173 ·135	·310	—	91,400		Fine crack at 74,500 lb. Well cracked at 79,800 lb.

Tested December 30th, 1902. Initial stress, 10,000 lb.

Results of Tests on Beams.

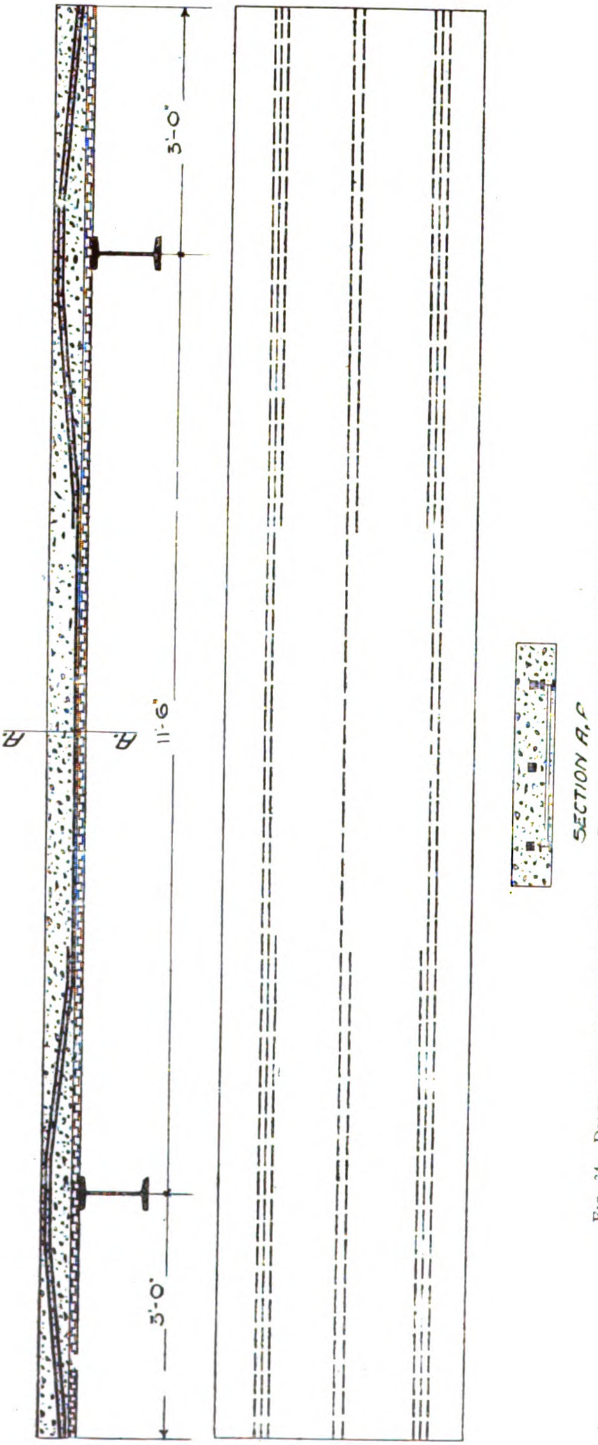


FIG. 34. DIAGRAM SHOWING ARRANGEMENT OF REINFORCEMENT IN SLAB TESTED BY THE LEWIS CONSTRUCTION CO., LTD.

LEWIS CONSTRUCTION CO.'S TESTS.

A test on a two months' old beam was made by the Lewis Construction Company on January 7th, 1909. This beam was T shape, consisting of No. 2 section dovetail corrugated sheeting (27 gauge) and No. 8 $\frac{3}{4}$-in. wrought iron round rods placed as shown in the diagram (*Fig.* 35). The concrete was gauged 1 part cement to 2 parts sand and 4 parts of ballast, crushed to pass a $\frac{3}{4}$-in. mesh sieve. The span was 9 ft. 6 in. in the clear.

The result was as follows :—

Load Applied			Deflection (Approximately)
2 tons	...	...	Nil
4 ,,	...	...	$\frac{1}{32}$ in.
5 ,,	...	...	$\frac{1}{8}$,,
6 ,,	...	...	$\frac{1}{4}$,,
7 ,,	...	...	$\frac{3}{8}$,,
8 ,,	...	...	$\frac{1}{2}$,,
9 ,,	...	...	$\frac{5}{8}$,,
9 ,,	44 lb.	...	broke

It was found on inspection that the rods had not been broken, but only bent, and that the fracture had taken place exactly in the middle.

On August 7th and 8th, 1908, the same firm tested a reinforced concrete slab floor, $5\frac{3}{4}$ in. thick and 11 ft. 6 in. clear span. The slab was constructed on July 7th, so that it was one month old at the time of testing. The same was placed on two supports with overhanging portions, the intention being to make the slab act as a continuous beam, but it was noted that the cantilever portion slightly lifted owing to insufficiency of weight for the anchorages of these parts, and the deflection was therefore increased. However, the loading and deflections were as follows :—

Load Applied			Deflection
2 tons	...	...	Nil
4 ,,	...	...	$\frac{1}{4}$ in.
6 ,,	...	...	$\frac{3}{8}$,,
8 ,,	...	...	$\frac{11}{16}$,,
10 ,,	...	...	$1 \cdot \frac{1}{16}$,,
12 ,,	...	...	$1\frac{5}{8}$,,
14 ,,	...	...	$2\frac{1}{4}$,,
14 ,,	8 cwt. 2 qrs.		$2 \cdot \frac{7}{16}$,,

At the time the loading was discontinued it will be seen that the total load was 14 tons 8 cwt. 2 qrs. 18 lb., which is equal to 8·4 cwt. per sq. ft. This load has been left on the slab until the present date, and no further deflection has been noted. The slab is 3 ft. wide, and it was constructed with 1¼ in. by 1¼ in. by ¼ in. H bars, placed 2 ft. apart at the centre, and a sheet of dovetail corrugated metal inserted between, and, in addition, six 9/16 in. by ⅝ in. bars were placed over the supports and cranked downwards as shown in Fig. 34 for the purpose of giving continuity and reinforcing the cantilevers. Three of the rods ran the full length of the slab, being continuous, and therefore in addition to the sectional area of the H bars we must add these three 9/16 in. by ⅝ in. bars. The concrete was gauged 1 part cement to 2 parts sand and 4 parts ¾-in. ballast.

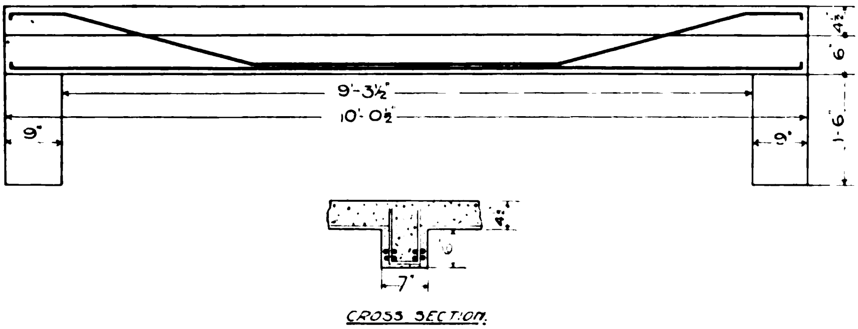


Fig. 35. Diagram showing arrangement of Reinforcements in Beam tested by the Lewis Construction Co., Ltd.

(*To be continued.*)

RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

A General Meeting of the Concrete Institute was held at the Royal United Service Institution, Whitehall, S.W., on January 20th, and the attendance was considerable.

The Paper on this occasion was presented by Mr. Ernest R. Matthews, A.M.Inst.C.E., F.R.S.Ed., Borough Engineer of Bridlington. The paper was a very interesting one, and the discussion which followed also calls for favourable comment. We are giving a lengthy summary of both.

REINFORCED CONCRETE CHIMNEY CONSTRUCTION.

PAPER by ERNEST R. MATTHEWS, A.M.Inst.C.E., F.R.S.Ed.

(Borough Engineer of Bridlington.)

Mr. W. T. Hatch, M.Inst.C.E., Metropolitan Asylums Board, Member of Council of the Concrete Institute, presided.

MR. ERNEST R. MATTHEWS, Reader of the Paper.

THAT reinforced concrete was considered by American engineers and architects to be suitable for the construction of chimneys, the author suggested, might be gathered from the fact that during the past seven years one firm alone had erected nearly a thousand such chimneys in America, under the direction of some of the most able engineers and architects in that continent.

He divided the subject-matter of this paper into—(A) The advantages of using reinforced concrete for the construction of chimneys. (B) The erection of reinforced concrete chimneys in Great Britain. (C) A tabulated statement giving particulars of a number of these chimneys constructed in the United States. (D) The methods of calculating the stresses and strains in such chimneys, and reason for the recent failure of a shaft in the United States. (E) The effect of excessive heat upon concrete and reinforcement. (F) General notes with respect to reinforced concrete chimneys.

Advantages of using Reinforced Concrete in Chimney Construction.—It had been found in America that reinforced concrete chimneys could be built by a well-organised firm at less than one-half the cost of a brick shaft, and that the larger the shaft the greater the saving, since a large brick chimney of considerable height must have brickwork of great thickness at its base to prevent overturning.

It was also usually found that in districts where brickwork was expensive concrete was also costly, so that there was no difference in the ratio of their respective cost. It would appear, therefore, that on the ground of economy reinforced concrete had much to recommend it as a material for the construction of chimneys. Saving of space was often a great consideration. In a shaft 300 ft. in height, for example, the brickwork at the base, according to the building regulations of our English cities and boroughs, would be about 4 ft. 10 in., whereas the thickness of the walls at the base of a reinforced-concrete chimney would probably be as follows: outer wall 9 in., inner wall 5 in., with a space of 4 in. between the two walls. Therefore considerable economy of space was attainable by the employment of reinforced concrete for chimney construction. The weight was also less than a brick shaft, which naturally arose from the saving of space, and was a matter of the greatest importance where a treacherous soil had to be built upon.

Reinforced-concrete chimneys had been erected in the United States for some years past, and the author knew of only one failure. Reinforced concrete lent itself admirably to chimney construction, a recommendation which could not be so confidently asserted with regard to brickwork. The author considered that a reinforced concrete chimney, if properly designed, was of greater stability than one built of brick, since the former had no joints, whereas in a brick shaft failure might occur at any of the joints.

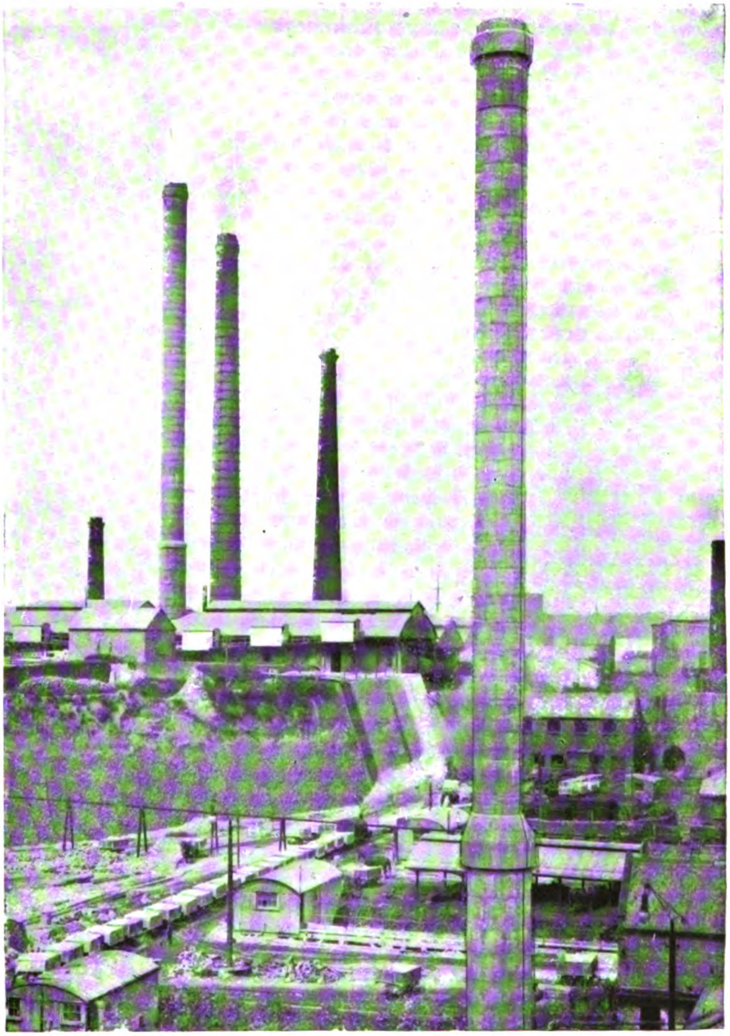


Fig. 1. View Showing the Two Reinforced Concrete Chimneys for the Associated Portland Cement Manufacturers' Works at Northfleet.

Once erected, reinforced-concrete chimney shafts required practically no repairs, while steel-plate chimneys required painting about every four years, and brick chimneys occasionally required repairing. The rapidity of execution of work was well known; a reinforced-concrete chimney could be erected in half the time that it took to build a brick shaft.

These were some of the advantages which the author claimed for the use of this material in chimney construction.

Typical Examples of Reinforced-Concrete Chimneys in Great Britain. —The author then referred very briefly, before giving American examples, to one or two of the reinforced-concrete chimneys which had been erected during the past few years in this country. Several of such chimneys might be referred to, but the object of the paper was to deal chiefly with those erected in the United States, so that only a few were mentioned.

Chimney at Messrs. Lyle & Sons' Works, London, E.—The shaft erected a short time ago at the works of Messrs. Abraham Lyle & Sons, Ltd., of London, E., was a good example of what could be done in reinforced concrete. This chimney was 261 ft. in height and 20 ft. in diameter. The walls, for the upper two-thirds, were 8 in. in thickness, double walls being built in the lower third. The reinforcement consisted of vertical bar consisting of $1\frac{1}{4}$-in. × $1\frac{1}{4}$-in. × $\frac{3}{16}$-in. **T**'s and horizontal rings of $\frac{5}{8}$-in. steel rods spaced at 18-in. centres, vertical bars extending into the concrete foundations.

Chimneys at Briton Ferry, Glamorgan, and at Belfast.—The chimneys recently erected for the Cape Copper Co., Briton Ferry, Glamorgan, and for Messrs.

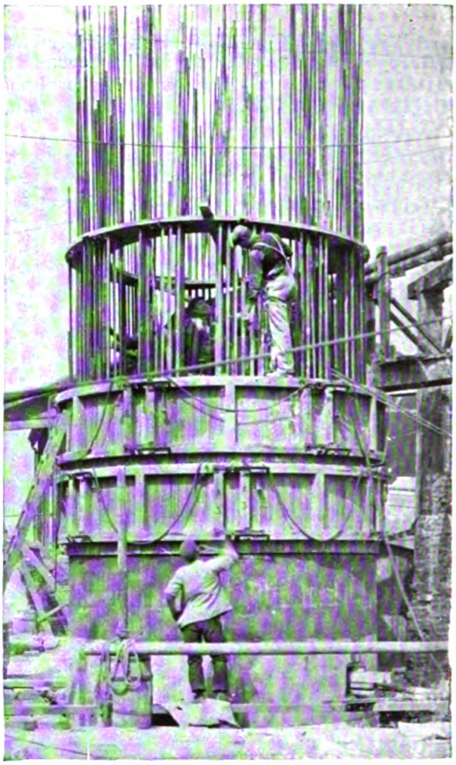
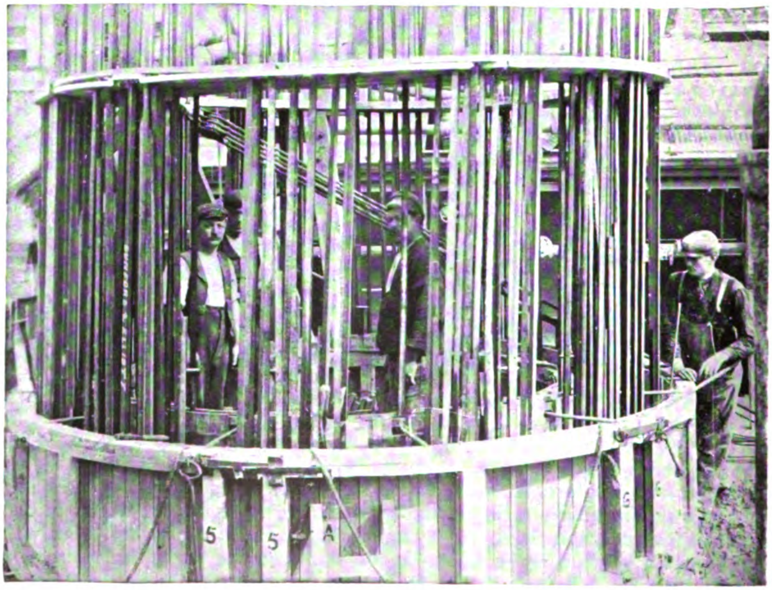


FIG. 2 VIEW OF CHIMNEY IN COURSE OF CONSTRUCTION.



View Showing Chimney in course of construction.

FIG 3. REINFORCED CONCRETE CHIMNEY FOR THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS' WORKS AT NORTHFLEET.

J. & S. M. Greeves, Ltd., of Belfast, were also good examples. The dimensions were as follows: heights, 150 ft. and 200 ft.; diameters of outer shells, 13 ft. and 8 ft. 6 in. respectively.

Large Chimney at Northfleet.—This had recently been erected; it was 8 ft. 6 in. inside diameter, and 247 ft. in height above bottom of foundations, and was a fine example of reinforced-concrete construction (see *Fig.* 1). The foundations, the bottom of which were 35 ft. below ground-level, were remarkably shallow, being only 2 ft. tapering to 4 ft. in thickness, and 18 ft. × 18 ft. in area. A 6-in. baffle wall was constructed across the lower portion of the shaft, and the thickness of the shell up to 62 ft. above the ground-level was as follows: outer shell, 12 in.; cavity, 4 in.; inner shell, 4 in. Above this the chimney consisted of a single shell 9 in. in thickness. The reinforcement in the foundations consisted of 1¼-in. × 1¼-in. × $\frac{3}{16}$-in. **T**'s, and in the shell of horizontal rings of steel ⅝ in. diameter, spaced 18 in. apart, and vertical bars formed of 1¼-in. × 1¼-in. × $\frac{3}{16}$-in. **T**'s. *Figs.* 2 and 3 show the larger chimney in course of construction.

Smaller Chimneys at Northfleet.—Although a smaller chimney, 130 ft. high, the one recently erected at the Kinght, Bevan and Sturge Works at Northfleet (see *Fig.* 1) was of much interest. The shallow depth of the foundation was rather remarkable. While this was 15 ft. 6 in. square in area, the depth was only 3 ft., tapering to 2 ft. The inside diameter of the chimney was 5 ft. The bottom of the foundation was 16 ft. below ground-level, and this was reinforced by 1¼-in. × 1¼-in. × $\frac{3}{16}$-in. bars. For a height of 41 ft. above ground-level the outer shell was 6 in., the inner 4 in. in thickness with a 4-in cavity between; 9-in. diameter air inlets occurred at intervals; above this the chimney consisted of a single shell only 5 in. in thickness. The shell was reinforced by means of vertical bars and horizontal rings, the former being deflected around smoke flues. The vertical bars consisted of 1¼-in. × 1¼-in. × $\frac{3}{16}$-in. **T**'s, the rings being ⅝ in. diameter steel rods placed 18 in. apart. At the bottom of the offset flat rings 3 in. × ½ in. were inserted. *Fig.* 5 shows the smaller chimney in course of construction.

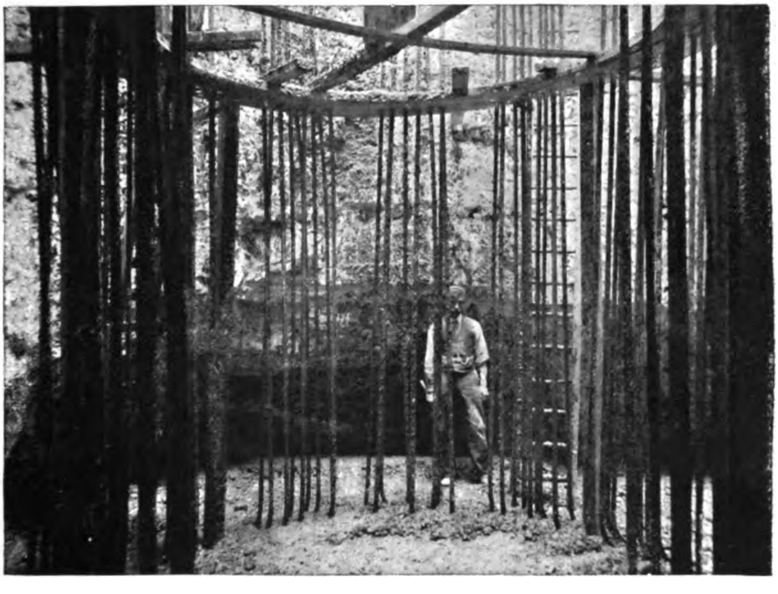


FIG. 4. VIEW SHOWING FOUNDATION OF REINFORCED CONCRETE CHIMNEY AT NORTHFLEET.

The two foregoing shafts had been erected for the Associated Portland Cement Manufacturers, at their works at Northfleet.

The author then gave examples of various reinforced concrete chimneys which had been erected in America.

Methods of Calculating Stresses in Reinforced Concrete Chimneys.—With regard to the recent failure of a chimney in the United States the conclusions arrived at by the authors of an article on "The Design of Reinforced-Concrete Chimneys," which appeared in *Engineering* in March, 1908, were interesting and instructive. They said:—

"It would appear, therefore, that while the thickness of concrete was ample, there was not nearly enough steel to ensure safety, and, of course, this deficiency in steel greatly increased the pressure on the concrete by throwing the line of zero stress away from the centre of the chimney, and thus leaving a very small proportion of the section in compression. . . . The failure of this chimney cannot be said to cast any reflection upon the use of properly designed reinforced concrete for such structures."

Effect of High Temperatures—In order to obtain some reliable data regarding this important matter the author determined to carry out two series of tests—one dealing with concrete that had only had a short set, the other with concrete that had at least two months' set—and he gave detailed particulars of these tests.

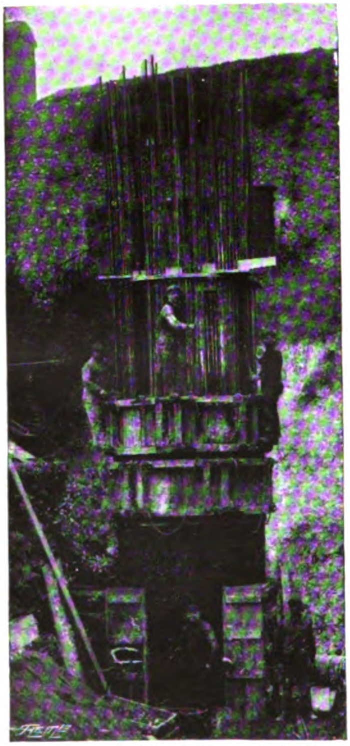


FIG. 5. SMALL REINFORCED CONCRETE CHIMNEY IN COURSE OF CONSTRUCTION.

The author determined to obtain some information regarding the condition of the concrete and reinforcement in an existing reinforced concrete chimney, and he acknowledged his indebtedness to Mr. H. K. G. Bamber, F.I.C., of the Associated Portland Cement Manufacturers (1900) Ltd., who kindly supplied him with some most useful information on this subject.

Mr. Bamber informed the author that in order to ascertain if concrete deteriorated through the effects of heat he inspected on several occasions the face of the concrete shell inside the reinforced concrete chimney at the works of his firm at Northfleet, and he failed to observe any signs of deterioration. Not contenting himself with this, he subjected the ash in this chimney, on various dates, to an analysis, and compared this with an analysis of the ash taken from the base of a brick Custodis shaft, also at his firm's works at Northfleet. The comparison was most interesting; there was very little difference in the percentage of insoluble residue present, which residue would, of course, include any portions of sand that might, from deterioration, be coming away from the inside of the inner shell of the concrete chimney.

Mr. Bamber kindly had a small hole cut out for the author in the base of the inner and outer shells of the reinforced concrete chimney at Northfleet for the purpose of exposing a portion of the reinforcement. These were made just over the flue opening where the heat would be most likely to affect the concrete. The result was most satisfactory, the steel being in as good condition as when first inserted in the concrete.

The author's experiments led him to the following conclusions:—

(1) That neat cement behaved better under great heat than out of it. The average compressive strength of 2¾-in. cubes placed in flue for 28 days, after having remained in air for 14 days, was 52·6 tons on the cube compared with 33·6 tons when placed in water for a similar period; the tensile strength per sq. in. of the briquettes being 1,008 lb., compared with 850 lb. in the water test.

(2) That concrete (3 parts standard sand to 1 part Portland cement) if not well set behaved very badly under heat. The average tensile strength of briquettes 1-in. section (3 to 1) placed in flue for 28 days, after being in air for 14 days, was 105 lb., compared with 310 lb. at 7 days, and 460 lb. at 28 days in water.

(3) That if the concrete had had at least a two-months' set before heat was applied a temperature of 900 deg. Fahr. would not affect it in the least. This might be taken as the safe temperature in reinforced-concrete chimneys.

(4) That the 3 to 1 specimens in these tests giving such poor results pointed to the necessity of having no voids whatever in any concrete work, it being well known that 3 to 1 briquettes made of standard sand contained a considerable quantity of air spaces

(5) That only allowing the specimens 14 days before subjecting them to the heat was far too short a period in actual work. The greatest advantage was obtained by letting the heat get at the concrete after the longest time has been given for the cement to set.

(6) Concrete mixed with 10 per cent. of water (which should be the maximum in work of this class) would contain only about 1 per cent. of free water after a two-months' set. Heat should not be applied to concrete until the latter had had a two-months' set, a longer set than, say, three months would be preferable.

Generally reinforced-concrete chimneys had been objected to on the following grounds: (1) because occasionally during the hardening of the concrete hair cracks have been noticed on the concrete surface, and it had been thought that these may affect the temperature in the chimney and consequently the draught; (2) because chimneys constructed of this material were, in the opinion of some, unsightly.

With regard to the first objection, the author admitted that hair cracks did frequently occur when a large concrete surface was setting, but these were only skin deep, and in the case of a chimney could not possibly affect the internal temperature. As to the second objection, there was no reason why a reinforced-concrete chimney should be unsightly; it could be made ornamental if required so, and at no great extra cost.

The aggregate in the concrete in the case of chimneys was *fine*, but coarser material was used in the foundations. All concrete was well tamped. The factor of safety used by well-known chimney builders in America was between 4 and 5, and provision was frequently made for stresses which would be set up by a maximum wind velocity of 100 miles an hour, a velocity which was practically unknown. It had been the custom both in Great Britain and America to take the maximum wind pressure at 50 lb. per sq. ft. on a square shaft, and half this on a circular shaft.

No tensile stresses on the concrete were allowed for. The chimneys were well anchored by continuing the vertical steel bars into the foundation and then bending them through 90 degrees. The large number of vertical bars in the outer shell was divided into two portions, one-half of which were bent to reinforce the upper part of the foundation slab, and the other half, which alternated around the chimney, were bent at the bottom of the slab. All of the vertical bars in the inner or expansion shell were carried down into the foundations and bent over. Continuity in the steel was provided by overlapping the ends of the bars at least 30 diameters. All wind stresses were provided for by the vertical steel reinforcement and temperature stresses by the horizontal rings or plain round rods (as already described) bent to a true circle. These latter were spaced not more than 18 in. apart vertically, and, as in the case of joints in the vertical steel, the breaks in the bars were staggered so as to occur unevenly and form no plane of cleavage. Additional ring steel was placed at any bends in the vertical steel, as at the offset and foundation. In designing a chimney the stresses were computed at several sections.

The foundations were frequently reinforced by two meshes of steel bars as already explained, the top mesh running at right angles to the side of the foundation for its full width, the bottom mesh consisting of bars laid diagonally in each direction at an angle of 45 degrees from the side of the foundation. Additional vertical bars should be placed on the sides of the smoke opening to take the place of those omitted in that opening, and additional bars placed above and below the smoke opening to furnish lintel and sill reinforcement.

The forms used in the construction of reinforced chimneys were necessarily somewhat complicated and intricate.

The Chairman then called upon Mr. William Dunn, F.R.I.B.A., to open the discussion.

MR. WILLIAM DUNN, F.R.I.B.A.

Failures.—There was no doubt that reinforced concrete was a suitable material for chimney construction. There had been failures, but these failures had been from faulty construction or design, from defects which could be controlled. He noted that Mr. Matthews only knew of one failure, but in the investigation made by Mr. Sandford E. Thompson for the Association of American Portland Cement Manufacturers in 1907 (which, if he remembered aright, was an investigation into some 400 chimneys which had then been built), he mentioned more than half a dozen complete failures—blown down, or fallen down, or torn down because of their defective condition. He said that the total failures were about 2 per cent. of the chimneys reported on ; another 2 or 3 per cent. were of doubtful safety, which, of course, was a very high percentage of failures in chimney building. This, however, was in the very early stage of reinforced concrete chimney building, and the American builders of such chimneys had no doubt learnt something from bitter experience.

He had built a brick chimney about 130 ft. in height some ten years ago, and it was in use but a very short time when he was informed that it had badly cracked. He examined it and found this to be the case, but the cause was not due to any defect in the design of the chimney ; it was due to excessive heat from the boiler flues. The temperature of the escaping gases at the base of a chimney should not exceed 500° to 600°. In this case an automatic stoker had been fitted to the boiler, the coal supply had caked, and the supply of oxygen was insufficient for proper combustion. He found the temperature at the base of the shaft about 1,400°, in place of some 400° to 600°, which would have been the temperature with proper stoking. When the stoking was put right, and the heat reduced to ordinary temperature, the cracking ceased. Brick chimneys, as the chairman had said, usually showed cracks. It would be strange if they did not, as the temperature inside was so much above that outside, especially when there was a gale of wind and sleet. The inside lining in the lower part was a protection, but the temperature all up the shaft remained high; indeed, it was only about 20 per cent. or 30 per cent. less near the top than at the bottom, so that at the top of the inside lining, where the shaft was not protected, one would expect to see cracks. From photographs of reinforced concrete chimneys which he had seen both horizontal and vertical cracks were to be found which were sufficiently alarming but not necessarily dangerous. At that point there was also usually a reduction in the diameter of the shaft, and special care was required with the reinforcement.

Weight of Chimneys.—Mr. Matthews mentioned the lesser weight of reinforced concrete chimneys as an advantage. So it was in some ways, but not in all. For instance, in considering the stability of the chimney, the effect of this lesser weight on the stresses in the steel and concrete was very considerable. The greater the weight of the chimney in relation to the exposed surface the less the relative effect produced by the bending moment due to wind. In a well-designed brick chimney there was no tension on the windward side, as brick cannot resist tension ; but in a reinforced concrete chimney one might perfectly well allow the line of action of the wind and dead load to cut any horizontal section beyond what was called the kern—that is, the part which corresponds to the middle third in a plain square section—as the steel reinforcement took up any tension. That was a very fortunate thing, as otherwise a reinforced concrete chimney would have too little weight to prevent tension on the windward side.

Temperature.—One difficulty in chimney design was that one was obliged to proceed by trial and error, as in the case of arches, adopt a design and test it for stability. Assuming the stability of the chimney, there remained the question of its durability. The durability was largely a question of temperature. It appeared from experiment with tubes, such as had been described by Mr. Matthews, and from experience with actual structures, that temperatures of 400° to 600°, such as were usually met with at the base of chimneys, did not injuriously affect gravel concrete. It was only after a temperature of 750° or so is reached that injury resulted. This left a comparatively small margin in case of excessive temperatures. Of course, concrete formed of limestone should never be used for work exposed to great heat. The tests made by Professor Norton had shown that limestone concrete begins to lose strength at temperatures under 500°. Mr. Matthews' experiments were made with concrete with an aggregate of clinker exposed to fire, but actual experience with chimneys was worth more than laboratory tests, and we were very much indebted to Mr. Bamber for his exceedingly interesting report upon an actual chimney. Mr. Bamber is a careful and accurate reporter, and very great importance should be attached to what he says.

Consistency of the Concrete.—One or two points not mentioned by the speaker occurred to him. One was that a slightly wetter mixture than usual was desirable to secure proper adhesion to the bars, though Mr. Matthews would rather limit the water used. Proper adhesion to the bars was a very important thing, and the failure in some of the American chimneys investigated by Mr. Thompson was due to want of adhesion between the concrete and the steel.

Another point was that circular rods seem preferable to T bars for the reinforcement, owing to the special care required in tamping the concrete round T bars to secure adhesion. Then there was the question of time ; Mr. Matthews had told them that there was a saving of about half the time. Personally, he would not like to claim that advantage for reinforced concrete chimneys. In all chimneys the rate of execution is limited to a few feet in height per day. It was specified that there should not be more than a few feet in height per day, and he doubted the wisdom of going further with reinforced concrete than brickwork.

MR. C. PERCY TAYLOR, A.M.Inst.C.E.

He thought this subject should be looked upon from two rather distinct points of view. The first was purely a matter of the chimney as a structure, and when one considered that all the stresses that the structure had to bear were due first to weight, and secondly to bending due to wind, they would agree that reinforced concrete was an ideal substance for chimney construction.

Temperature Tests.—The more important point of the discussion seemed to him the question of heat. The author had given them the results of a good many tests which had been made on samples placed in flues, but he thought he was right in saying that none of the samples had been tested after being more than 28 days in the flue. He did not think that was really nearly long enough to give any satisfactory and reliable result. He had been making for some time experiments with samples, and had some in the flue up to 15 months. They were made with a 3 to 1 mixture, rotary cement and sand, not standard sand. Some of these samples were still in the flue, but up to the present he found that the 2¾ cubes could be relied on to stand a stress of 3,000 lb. to the sq. in., and that seemed very constant, as similar material mixed in the same way would go much higher, to about 5,000 lb. in air, but it was subject to rather violent variations, to which nearly all concrete is subject when tested for long periods. The results of the cubes in the flue were very much more constant at about 3,000 lb. to the square inch. The tensile results were not what one would call good. They came out at an average of about 140 lb. per sq. in. The question of tensile stress did not really come into the design of a chimney or any other concrete structure; but, in his opinion, it indicated—as there must be some connection between tension and sheer—that one ought not to rely on a concrete chimney taking any sheer, whatever one might consider in an ordinary structure not subjected to heat.

While the cubes and tensile samples had been in the flue, they had had some bars 5 in. square, with brass plugs let in on all four sides to 33¼ in. centres as a convenient length, and his friend Mr. Glenday had been measuring them very carefully by periodically taking them out of the flue to see whether any change of length took place. They had had some of the bars plain, and some reinforced with ¼ in. rods. The result of these tests was rather peculiar. They found that when the sample was put in the heat and measured after seven days, there was in the plain samples a very marked contraction amounting to about a twelfth of 1 per cent., but when the samples were reinforced the bars had the effect of reducing that contraction to very much less. The difference between the plain samples and the reinforced samples amounted to about one-twentieth of 1 per cent. He had been seeking an explanation of the difference. It appeared obvious at first sight that it was due to the bar holding the concrete in what he might call an elastic way, but if one assumed that the concrete had really wanted to shrink, and had been held to its normal length by a steel bar, it must have produced a tensile strain in the concrete of something like 2,000 lb. to the sq. in., and it must necessarily have cracked. As a matter of fact, although there might be minute cracks, he had not found any when he cut up the bars himself with a hammer and chisel, and he thought that the bars had in some way the power of preventing the concrete contracting. He wanted to explain that it was not simply holding it with a tensile strain, but preventing it contracting at all. The fact that these samples had not actually visibly or apparently cracked showed, he thought, that the heat did not of itself tend to crack the concrete. He was not here referring to the temperature gradient through the shell which put an actual stress on the material.

Bond Tests.—After these samples had been used for taking these measurements, some of them were used for bond tests. The samples were cut in halves, leaving a portion of the bars in each end of the concrete block, and the two ends were then pulled apart. The samples were not really prepared for the test, and the fact that there were four bars made it quite impossible to secure an equal stress on them all, and the results were very variable indeed, the surface adhesion varying from 20 lb. to 370 lb. per sq. in.; but they found in one of the samples that it had been accidentally cracked, one of the 20-lb. ones, and in another of the bad ones the bond was very bad indeed. He put that down to the stuff being made up too dry. It was made up by an extremely careful and experienced man, but he entirely failed to get a good bond, and he thought that was a very strong reason against using dry concrete. Generally speaking, although some of the results were bad, he thought that with wet concrete wel rammed round one would be able to rely on using for practical purposes a bond of 50 lb. per sq. in.

Cracks.—The author had restricted himself entirely to what he called "hair cracks which had developed during the hardening of the concrete." Now, he (Mr. Taylor) thought he might say the cracking of the chimneys was really the one thing which had retarded their adoption in this country, and it had to a certain extent retarded their use in America. Mr. Thompson, as Mr. Dunn had pointed out, had investigated this matter very closely indeed, and he had come to the conclusion that with proper distribution of horizontal reinforcement all cracking could be entirely avoided, and he (Mr. Taylor) also thought that the stresses produced by the temperature gradient through the shell could really be subjected to mathematical treatment. He also thought that the cracks could be very much reduced, or, at any rate, made very much less severe, by the use of some sort of deformed bars.

Mr. Dunn had mentioned the objections to T bars. He thought that objection was very well founded. He recently cut two holes himself in the large chimney at Northfleet, where there were cracks, and he thought that the T bar was much too big for the amount of steel. It tended to cause a bad crack, where a round bar probably would not have such a bad effect. It was interesting to state that, though this crack was ⅛ in. wide and only ¾ in. deep, the steel they came on was absolutely sound, and there was not a sign of corrosion of any sort in either of the places where they cut into it.

Consistency of the Concrete.—As to specifying 10 per cent. of water for use in the concrete, he thought it was a very bad practice to specify an amount. It must differ with the cement, and the sand, and with the weather. What they wanted to get was a quaking concrete which could be rammed round the bar, a little water showing at the top when one had finished ramming—this was to say, wet without being too sloppy.

Linings.—With reference to the question of linings, anybody who had watched a concrete chimney being built must have realised that the building of the lower lining concurrently with the outer shell must cause considerable expense and delay. The air space between the two was only generally four or five inches. Into that space one had to get the inner shuttering for the outer shell, and the outer shuttering for the inner shell, and it was obviously impossible to build the next length until one had taken the shuttering out of the previous length. That, as a matter of fact, caused a considerable delay. He thought it would be far better to build the chimney up without any lining at all, and to put that in afterwards. It could be put in quite well by building slight recesses about every 30 ft., much the same as in a brick chimney. If a slight recess was built in the shell a little extra reinforcement could be introduced if necessary, and either blocks or concrete rings put in afterwards. Spaces could be left behind to allow for expansion. He thought it was a mistake to stop the lining one-third of the way up. The temperature of gases, as Mr. Dunn had pointed out, was practically the same all the way up; they cooled very little. There was just the same necessity to line the top as the bottom, except for one reason, and that was that the bottom had to be thicker than the top, and a given temperature must necessarily produce greater stresses in a thick lining than in a thin one; but, except for that difference, the lining, if wanted at all, must be carried to the top.

MR. JAMES LYLE.

They had built a reinforced concrete chimney 261 ft. high by 20 ft. diameter and they had got some cracks in it. He thought that the shuttering used for the flue openings was not stiff enough, and that this part of the chimney should have been made a little thicker all round, and circular, by means of usual moulds, which would have made a much better job.

MR. W. JOHNSON (Engineer to Messrs. A. Lyle & Sons, Ltd.).

Tests on Blocks.—After listening to Mr. Matthews, he also was struck with the short time he had allowed the test blocks to remain in the flues. Before Messrs. Lyle decided to build a concrete chimney, they made several blocks about 3 ft. square by 6 in. thick. They reinforced and made them in a similar manner to ordinary reinforced concrete with small ballast, mixed very wet. Those blocks had been in the flues, and subject to about 600° to 700° Fahr. for 3½ years, and the concrete was practically destroyed. He knew that there was very little difference in expansion between steel and concrete, but there was some; and it was his opinion that this had had some effect on the concrete. In examining these blocks they found right round them, in the same plane as the reinforcement, definite fractures, not air or surface cracks.

Messrs. Lyle also made two blocks 2 ft. by 2 ft. by 8 in., with an aggregate of sand and cement (3½ to 1) mixed dry, and reinforced like the chimney. These blocks were well rammed. They had been in the flue 2½ years, and there was no comparison between these and the blocks they mixed wet. He did not agree with Mr. Thompson in his report on the American chimneys, that the concrete should be wet. He thought that a deformed bar should be used, and the concrete should be made, consistently with a good job, as dry as possible—with just a little moisture coming to the top, and that this concrete would stand heat much better than concrete which had been mixed wet.

Cracks.—After their chimney had been erected 12 months, they scaffolded up the inside, and examined the lining. They swept off the soot, which was about ¾ in. thick for a height of 90 ft., and found at the offset about seven or eight cracks, definite fractures. They varied from ⅛ in. to $\frac{3}{16}$ in. in width. They had not the same number of cracks on the outside as on the inside. They had about three or four on the outside, and these were much smaller. They had been up to the offset on the outside. He went up the scaffolding on the inside, and by a cradle on the outside, and examined the chimney at the offset, and he was speaking of what he had seen.

Lining of Chimneys.—With reference to the lining, he thought this should be built after the body of the chimney, and it should be quite separate and apart from the outside shell. The expansion on the inside shell was great. and if brought into contact with the outer shell, as Mr. Taylor suggested, it would destroy the outer shell. If he were building a chimney again, he would take the lining to the top, and allow an air space of not less than 10 in. to 12 in. A good many ducts should be made through the outer shell, so that air could pass freely into this space and keep the outside shell cool. Their inner shell was in a bad condition, but quite safe.

He thought the method of putting in a thick offset was wrong. The big mass of concrete and variation in diameter at that point causes unequal expansion in the chimney. It should be taken parallel from the top to the bottom, and with as little variation in the thickness as possible.

He did not believe in ornamental chimneys. By putting fancy shapes round the top and altering the symmetry of the chimney, trouble was brought in. If it were kept parallel, straight, and as equal in thickness as possible, it would give less trouble.

He had no hesitation in saying that if a reinforced concrete chimney were properly designed and properly built, it would be a good chimney. He thought there was as much in the building of a chimney as there was either in its shape or the material that was put into it. A responsible man should be on the chimney the whole of the time from start to finish, because so much was left in the hands of the men putting it up, and if one mistake were made the chimney would be faulty.

MR. ALFRED W. BROWN, A.M.I.Mech.E.

Generally.—He was a thorough believer in reinforced concrete for almost every class of constructional work, but was not inclined to think reinforced concrete suitable for the peculiar conditions of stress existing in a chimney.

There was first "an alternating temperature," sometimes changing from 1,500° Fahr. to 300° Fahr. in a very short period (say, in destructor chimneys, boilers with oil firing, or baking ovens); secondly, the inside of the chimney shell was hot while the outside was cold, and sometimes wet as well; and, thirdly, the whole structure swayed somewhat in a wind, so that the sides were alternating between tension and compression all the time, in addition to the stresses set up by the changing temperature inside the chimney

Mr. Matthews laid some stress on the saving of space, but he (Mr. Brown) thought it was comparatively rare that the amount of space saved by a concrete chimney was a consideration, as chimneys are, especially the larger ones, often outside the works altogether. Mr. Matthews also mentioned 4 ft. 10 in. as the thickness of a brick chimney 300 ft. in height. He thought that 3 ft. 3 in. would be found sufficient for a scientifically designed job. He thought Mr. Matthews's experiments hardly conclusive enough as regards the behaviour of reinforced concrete for chimney work, as all the various blocks had been exposed to the heat on *all six sides*, while the chimney was exposed *on one side only*, which was a much more severe condition.

In his "Conclusions" Mr. Matthews stated "that if concrete has had at least two months' set before heat is applied a temperature of 900° Fahr. will not affect it in the least. *This might be taken as the safe temperature for concrete chimneys.*" If this was the safe temperature for concrete chimneys he was afraid that their scope was somewhat limited, as chimneys for destructors, baking ovens, blast furnaces, and oil-fired plants had to withstand a temperature of 1,500° Fahr.

He thought Mr. Matthews's wind stress allowances were too empirical. He had computed the pressure on a round shaft as *half* the pressure on a surface at right angles, whereas it was nearly ·66 of this amount, the correct formula being :—

$$P = V^2 \times \cdot 66.$$

Where P = Pressure of wind in lbs. per sq. in.
„ V = Velocity of wind in miles per hour.

MR. OSCAR FABER, B.Sc., A.C.G.I.

Thickness of Chimneys.—With regard to the design of chimneys he would like to point out the desirability of keeping the thickness of the chimney as small as possible. This could be seen by the formula on one of the diagrams, which gave the thickness of concrete and the quantity of steel required in a chimney for given conditions of wind pressure and stress in the concrete and steel. It was easily shown from that that it was cheaper to stress the steel at a low unit stress and put a comparatively large quantity of steel in the shell, and then make the shell thin, than to adopt a thicker shell with a lower percentage of steel. They could design a chimney first of all with a fairly thick ring and see what quantity of steel had to be put in, and then design the same chimney with a thin shell and more steel, and work out the cost of the two chimneys. It would be easily found that it paid to adopt a thin wall.

The chief practical difficulties in making a successful concrete chimney were to prevent the chimney from cracking, and there was no doubt whatever that the thinner the wall was made the less tendency there would be for the concrete to crack, due to temperature stresses. The temperature stresses depended entirely on the difference of temperature between the inside and the outside of the shaft, and the thinner the shell was made the smaller would be the difference.

Cracks in Chimneys.—There was a point where the experience of the Associated Portland Cement

Manufacturers, who have three chimneys, was different from that of Mr. Johnson, and that was as regards the position of cracks. In the chimneys at Northfleet of the Associated Portland Cement Manufacturers, in every case the tendency was to crack at the outside of the chimney much more than at the inside of the chimney. One would expect, the inside being hotter, that it would expand more than the outside, and consequently cause cracks on the outside. It was very curious that the chimney at Messrs. Lyle's works should have cracked in exactly the opposite manner.

Mr. Johnson: He would like to know if Mr. Faber had been up to the chimney inside at the offset ?

Mr. Faber: He had, and they found hardly any cracks inside, even at the offset. Why he mentioned this point was because he thought the most useful object of any discussion like this was for everybody to add their experience together to see exactly where they differed. These differences suggested that temperature stresses were not the only ones which determined these cracks.

If cracks were more likely to occur on the outside, which was the experience in a large number of chimneys, then it was better to put the reinforcement near the outside of the chimney rather than at the centre of the ring, because reinforcement then prevented with much greater efficiency those cracks from taking place. He would just like to add, if possible, to Mr. Taylor's suggestion that the inner shell of a chimney was made much more effective if one let a cold draught through it, and therefore he suggested that, in making a shell in several pieces, perhaps it would be possible to leave small holes through the outside shell at the base of each section of lining so as to induce a cold draught to go up through these spaces and keep the temperature of the outside shell lower than it otherwise would be.

Stresses.—Another point was that their formula gave a means of determining stresses from statical conditions only, but in his opinion the stress in concrete chimneys was determined very largely simply by temperature and shrinkage stresses, and therefore it was always advisable in concrete chimneys to take fairly low unit stresses, because these temperature and shrinkage stresses made the conditions somewhat indeterminate. Also, in the case of chimneys, very little sacrifice in the way of economy was necessary in the adoption of low stresses, as explained before.

Bars for Reinforcement.—As regards the adoption of the deformed bar, he thought a deformed bar would be excellent for the circumferential reinforcement, because there was no doubt that with a deformed bar one tended to prevent large cracks appearing in a few places, and either one got no cracks at all, or there was a large number of very small cracks distributed throughout the length of the bar, which was an advantage. But personally he did not think it was good to use a deformed bar for the vertical reinforcement of chimneys, for the reason that when the concrete had been put into mould and was setting, there was, during the first day, a very considerable contraction, and if one had a deformed bar there was a tendency for it to prevent that contraction taking place, and for that reason the concrete would not become so dense as it would be if it were allowed to contract during setting, and when a chimney was subsequently heated, there would be a greater tendency to crack than if one had adopted the plain bar and the concrete had partially slipped while it was contracting, immediately after it had been placed in position.

Mr. Johnson mentioned that he thought the difference of expansion between concrete and steel had something to do with the formation of cracks, but he (Mr. Faber) suggested that the cracks were caused more by the contraction of the concrete than by any difference of expansion between the steel and the concrete. He was aware that the concrete in chimneys, and, in fact, all concrete kept at a high temperature, cracked more than other concrete, but he thought this to be due to the contraction being accelerated, and not to temperature stresses.

Mr. Johnson: He referred more particularly to the reinforcement of the blocks in their flues ; he had not in mind the fractures in the chimney. If anyone saw the blocks and the position of the reinforcement, he did not think there would be any doubt in their mind that the reinforcement had in some way or other caused the fractures. The cracks followed the line of the reinforcement so regularly that he could not help thinking that that was the cause.

Mr. Faber: He acknowledged that concrete kept hot did crack more than when kept cold, but he attributed this to the accelerated contraction of the concrete. The steel caused cracks by preventing this contraction from taking place. If the concrete were unreinforced, no stresses would be caused by the contraction, and no cracks would form.

MR. E. FIANDER ETCHELLS, F.Phys.Soc., M.Math.Assoc.

Comparison of Thickness.—One of the later speakers referred to a scientific design of a chimney 300 ft. high with only about 3 ft. 3 in. of brickwork at the base. That design must have been scientific, but it did not take into account the available floor space, because a chimney having walls only of that thickness would require a greater width of base than a somewhat thicker shaft. The author this evening mentioned 4 ft. 10 in. thickness of shafts. In the County of London they were bound by the Building Act of 1894, which requires a rather greater thickness still.

There is a very simple rule which will give the thickness required.

Let n = the *number* of half bricks in the thickness of the base of the shaft
h = the *height* of the shaft in feet.

Then $n = \frac{h}{20} + 1$

For example, in the case of the 300 ft. shaft $n = 16$ half bricks = 8 bricks = 72 in. = 6 ft. of brickwork at the base of the shaft.

Comparison of Stability.—The author had said he considered "a reinforced concrete chimney, if properly designed, was of *greater* stability than one built of brick, since the former had no joints, whereas in a brick shaft failure might occur at any of the joints." But to be fair between the two methods of construction, you should permit the brick shaft to also be properly designed. (Laughter.) Then, if it were properly designed, there should be no tension at the joints, and no tendency to failure by rupture at such joints.

Time Required for Erection.—The author further said that a reinforced concrete chimney could be erected in half the time required for a brick shaft, but to that half time the time required for the concrete to set must be added.

Ratio of Height to Diameter.—With regard to the tables of the chimneys the author gave one 200 ft. high and 7 ft. diameter. That meant that the ratio of height to its width was about 28. Under the Building Acts (probably throughout the Kingdom) a ratio of 12 was the maximum. There, of course, reinforced concrete had an advantage, but steel also had that advantage. He had designed, or inspected, or erected at least 40, and they all exceeded 12 diameters in height.

Line of Zero Stress.—There was a reference in the paper to the deficiency in steel greatly increasing the pressure on the concrete by throwing the line of zero stress away from the centre of the chimney. The line referred to is obviously the neutral axis of the cross-section. It should be noted that the method of finding the neutral axis differs from the method in the R.I.B.A. Report. In the paper on "Chimneys," the position of the neutral axis was apparently made independent of the ratio of steel in tension to concrete in compression, but dependent upon the stress, and therefore upon the loading. In the R.I.B.A. Report the neutral axis depended upon the percentage of reinforcement, but was independent of the load applied. This method of finding the neutral axis was very simple, and very ingenious.

Recovery of Concrete.—Concrete seems to be a very human material after all. It will be noticed that it occasionally gets prostrated by the effects of prolonged heat waves, but a month's hydropathic treatment seems to bring it all right again. (Laughter.) It may not, however, always be convenient to plug up the bottom of the chimney and fill it up with water to keep it in a fit and proper state.

Dynamics of a Chimney.—A certain amount of discussion had arisen with regard to the temperatures and the question of air spaces or openings in the outer shell. Sometimes for the sake of convenience a chimney was placed rather a long distance from the boiler. This had the effect of cooling the flue gases and incidentally reducing the temperature and draught of the chimney. Speaking only from the structural point of view, it would undoubtedly be an advantage to have openings in the outer shell so as to keep the shell cool, but the mechanical engineer or the electrical engineer would have something to say about that. His whole aim is to get what he calls a good chimney effect. Supposing he has a natural draught, he wants a good velocity of gases. The velocity of the gases through the shaft was dependent upon the difference of temperature between the inside and the outside. If he began to get air openings in the side here, he reduced the temperature of the gases and reduced the chimney effect, and thus reduced the power of the chimney as a draught-producing machine.

Effect of Heat on Steel.—If they had 900° Fahr. temperature on the inside of a chimney shaft, and about, say, 60 odd on the outside, in between the two there was a temperature gradient. Suppose the mean temperature to be about 400° Fahr., the steel might stand, but steel at a higher temperature than this would suffer a reduction of strength.

Safety Factor.—The paper stated that the factor of safety used by well-known chimney builders in America was between 4 and 5. He thought that it ought to be distinctly understood that that safety factor could only apply to the transverse resistance of the shaft, not its moment of stability about the base. It was a moot point whether that was really the safety factor of the chimney. A much more suitable figure, perhaps, would be the moment of stability divided by the overturning moment. Then, of course, your factor would be nearer 2 or 1½. In fact, in some of these chimneys it may be even less than that. They had not seen the drawings at close quarters, but he was afraid that some of those chimneys have had sand filling at the bottom. When they were pressed to adopt reinforced concrete chimneys, because of their absolute lightness, it must not be forgotten they might have to be loaded up with sand to bring the weight back again.

MR. E. R. MATTHEWS.

The Lecturer's Replies.—Mr. Dunn made some interesting remarks with regard to reinforced concrete chimneys, and said that limestone concrete should never be used in chimney construction

Mr. Matthews did not think he had named that in his paper, but it was certainly a point that should be taken note of, and with which he fully agreed. Mr. Dunn considered that 10 per cent of water in concrete that was to be used in a reinforced concrete chimney was an amount to which one should not limit oneself, but that a wetter mixture might be used. He did not at all agree with Mr. Dunn in this. One or two speakers to-night had agreed with the statement contained in his paper that 10 per cent. was as much water as should be added to concrete where that concrete was to be subjected to heat.

He was very pleased with Mr. Taylor's interesting remarks, especially his calculations with regard to the strength of reinforced concrete chimneys. With regard to the methods of calculating the strength of such chimneys, Mr. Taylor said that the 28 days' test of his (Mr Matthews') blocks was not sufficient; that a longer test would have been very much more satisfactory. That, of course, would apply equally with regard to all tests. The longer period one's tests covered, the greater reliance might be attached to the result arrived at; but, in his opinion, when blocks had been subjected to a temperature of 1,250° for 28 days, surely if they were going to crack at all, they would do so in that time. Of the three blocks he took out of the flue, two showed no sign whatever of cracking, and they were absolutely white hot; they were white with heat for 28 days, and during that time no sign of cracking occurred or damage in any way, and, in his opinion, if they had been in the flue for double that time, they would have given the same result. With regard to the consistency of the concrete, Mr. Taylor preferred to use a wetter concrete than that which he (the lecturer) had named, and he also objected to the T bars. He also objected to them and thought that round bars were far more satisfactory for chimney construction than the T bars.

Mr Lyle and Mr. Johnson both referred to shafts of reinforced concrete that had been erected in connection with the works of Messrs. Abraham Lyle & Sons, and he was certainly very interested and somewhat startled to hear that cracks had occurred on the inside of one of these shafts, and no sign of a crack—at any rate, the cracks were not nearly so bad—on the outside of the shaft. This was contrary to what one would have expected, as in the American shafts which had failed cracks had occurred on the outside; at any rate, this was so with the one that he particularly referred to in his paper. The surest sign of cracking occurred on the outside, and when an inspection was made of the inside of that particular shaft the cracks were certainly visible, but they were not nearly so glaring as they were on the outside of the shaft, and he was rather surprised to find that the contrary had been Mr. Johnson's experience. He was glad to hear of this experience, and it would add considerably to their knowledge of the behaviour of reinforced concrete chimneys. Mr. Johnson said that if he were building a shaft again he would allow for a 12-in. air space. Well, to do that would mean considerably increasing the cost of his chimney; he would have to have a shaft very much larger.

In reply to Mr. Brown, the blocks he had referred to in the paper were heated on all six sides. Professor Woolston, in the experiments that he had been carrying out in order to ascertain the effect of heat on concrete, says, referring to concrete heated on one side only: "It shows that under that condition the concrete retains a large part of its strength," a much greater part of its strength Professor Woolston adds, than it does when heated on several sides. He says it can even be exposed to a temperature of 1,500° Fahr. for some hours without any detrimental effect.

With regard to the thickness of the chimney, he also thought it should be kept as small as possible; the thinner the wall the less tendency the concrete had to crack. That was, in his opinion, one of the reasons why the Americans built their chimneys with walls so extremely thin. With regard to the air inlets, Mr. Faber recommended air inlets through the outer shell into the cavity inside. He did not agree with Mr. Faber there, for the reason that Mr. Etchells had already given, that the mechanical engineer would certainly say this was considerably interfering with his work.

Mr. Etchells told them that the London County Council Regulations required a shaft 300 ft. in height to be 6 ft. in thickness at the base, so that he was well within bounds when he said 4 ft. 10 in. Mr. Etchells said also that the base of a reinforced concrete chimney, if it was in bad ground, should be considerably spread. It was so in most of the designs shown; the foundations extend to a considerable width, in some cases 36 ft. and 38 ft. square. The nature of the aggregate in the English chimneys was asked. He thought, but was not quite sure, it was Thames ballast. He fancied that Thames ballast was the aggregate used in the chimneys of Messrs. Lyle and those at Northfleet.

Mr. Lyle: It was all washed Thames sand, clean Thames sand, 3½ to 1, with no stone whatever. If you put stones in they would fly and split the concrete.

The Chairman: They were much obliged to Mr. Matthews for his valuable paper, and wished to pass him a cordial vote of thanks. (Applause.)

The meeting then terminated.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE SILOS AT HULL.

The grain silos described in this article were put up for Messrs. Joseph Rank, Ltd., at Hull by Stuart's Granolithic Co., Ltd., of 4 Fenchurch Street, London, E.C.

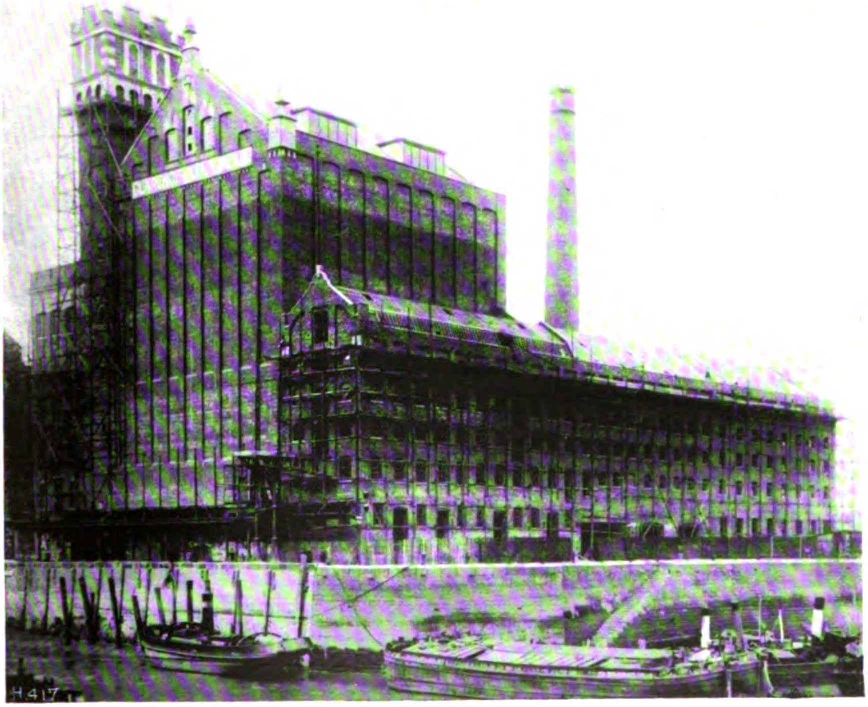
The building is one of the largest of the kind constructed of reinforced concrete in this country, the size and importance being clearly seen from the accompanying illustrations.

The total outside dimensions of the building are 86 ft. 3 in. by 79 ft. 9 in., the height being 90 ft. from hopper beam level.

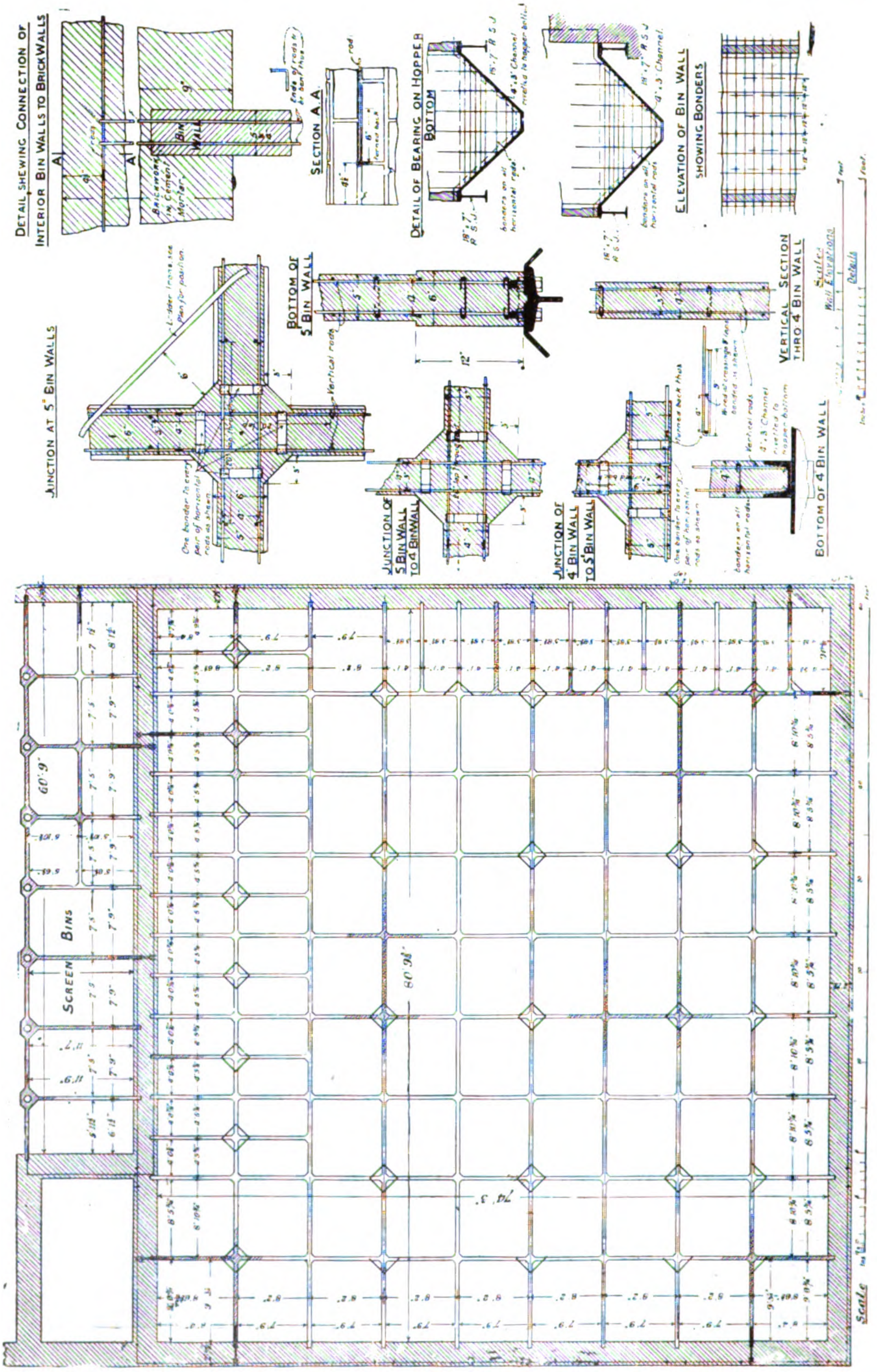
There are 81 bins, each 90 ft. high, also 12 screen bins 46 ft. high, and 7 rope race bins 30 ft. high. The other dimensions and arrangement will be seen on drawing on page 126.

All the divisional walls are 4½ to 5 in. thick.

The approximate capacity for grain in these silos alone is 11,000 tons, the

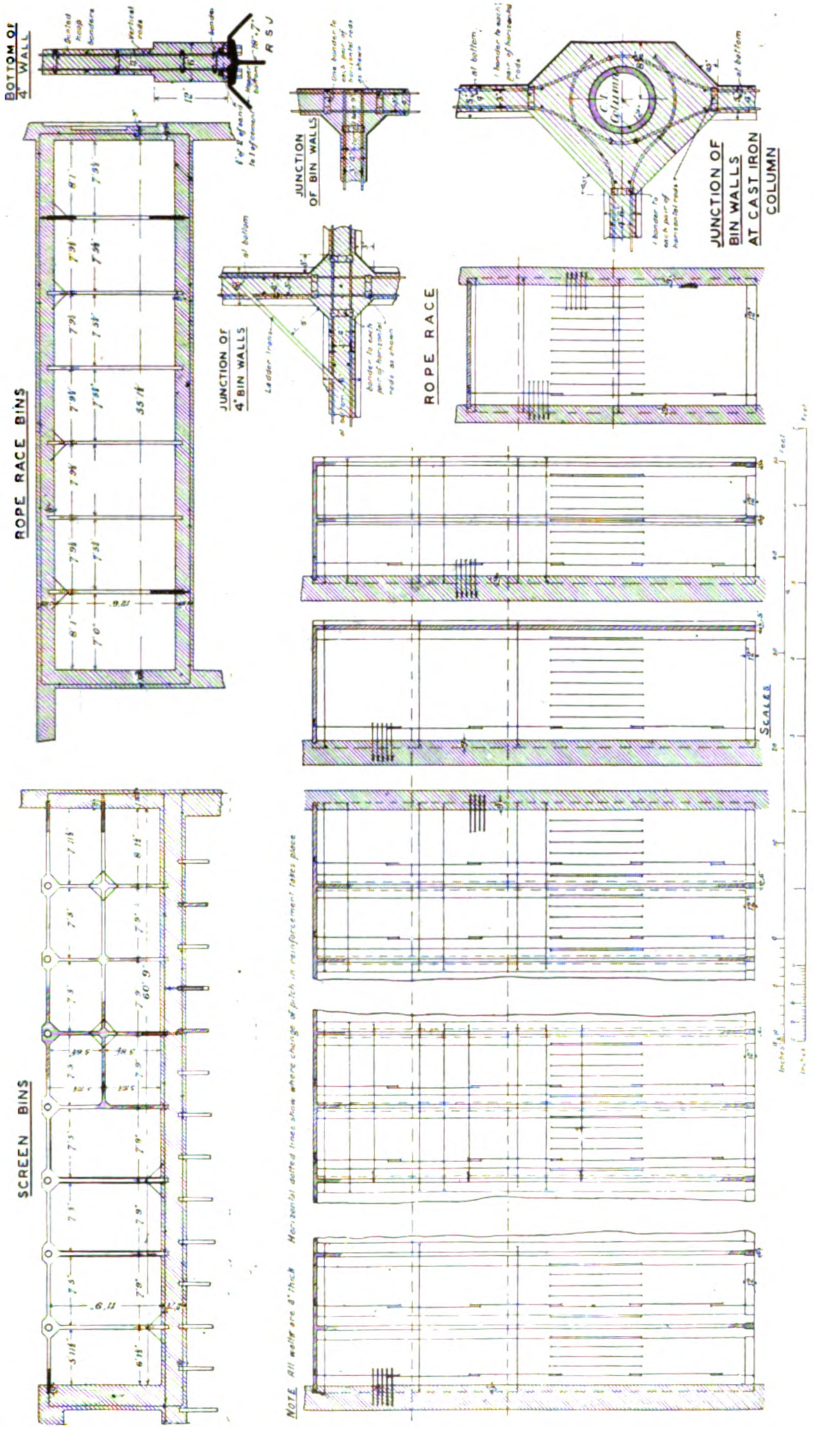


Reinforced Concrete Silos at Hull.


DETAIL SHEWING CONNECTION OF INTERIOR BIN WALLS TO BRICK WALLS
Brickwork in Cement Mortar
BIN WALL
SECTION A.A
DETAIL OF BEARING ON HOPPER BOTTOM
ELEVATION OF BIN WALL SHOWING BONDERS
JUNCTION AT 5" BIN WALLS
BOTTOM OF 5" BIN WALL
VERTICAL SECTION THRO 4" BIN WALL
JUNCTION OF 5" BIN WALL TO 4" BIN WALL
JUNCTION OF 4" BIN WALL TO 5" BIN WALL
BOTTOM OF 4" BIN WALL
Vertical rods
One bonder to every pair of horizontal rods as shewn
SCREEN BINS
60' 9"
80' 9¾"
74' 3"
Scale

Plan and Details of Bins.

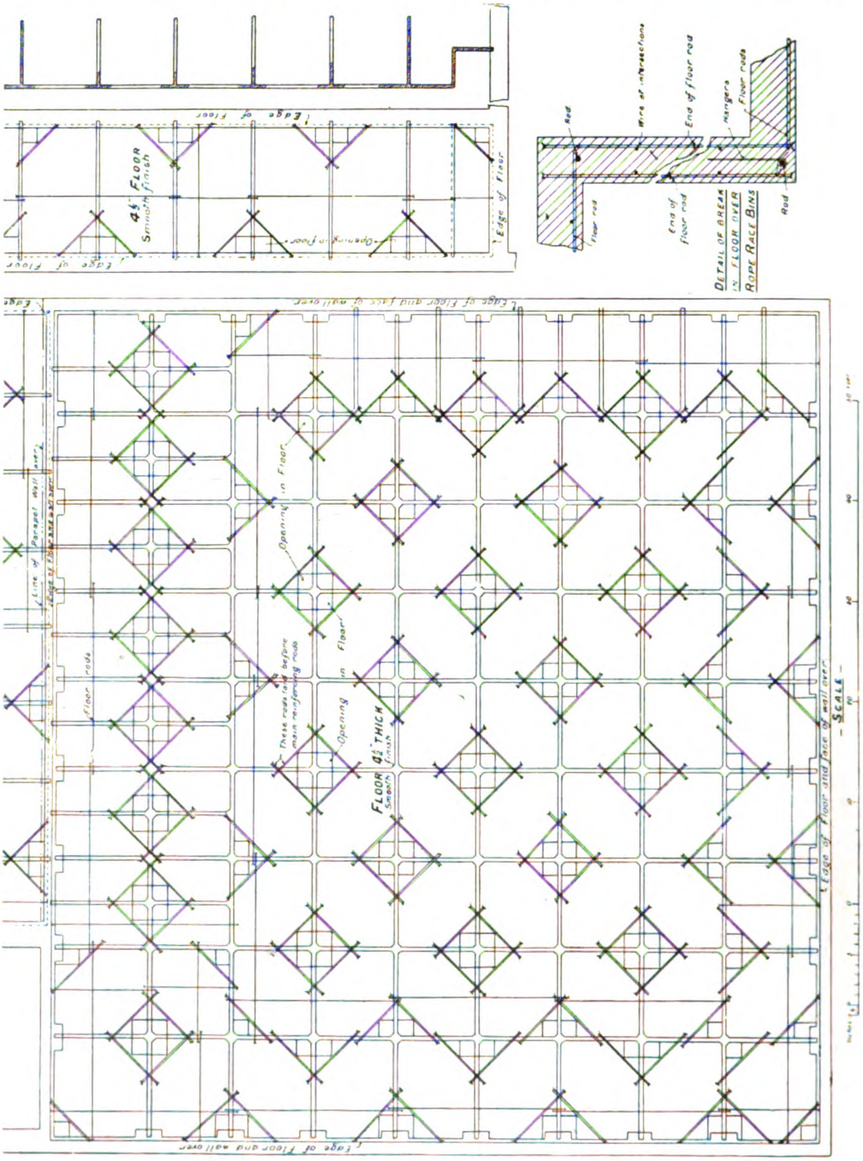
Reinforced Concrete Silos at Hull


BOTTOM OF 4" WALL
R S J
JUNCTION OF BIN WALLS
JUNCTION OF 4" BIN WALLS
Ladder irons
JUNCTION OF BIN WALLS AT CAST IRON COLUMN
column
ROPE RACE BINS
ROPE RACE
SCREEN BINS
NOTE All walls are 4" thick
Horizontal dotted lines show where change of pitch in reinforcement takes place
SCALES
Feet
Inches

Elevation and Details of Bin Walls.
Reinforced Concrete Silos at Hull.

construction of each part being such that one bin is equal to resisting its contents when fully loaded and the adjacent bins empty.

The architects for this work were Messrs. Gelder & Kitchen, of Hull. The system of reinforcement used was that of Mr. E. P. Wells, of Larkhall Rise, Clapham, S.W.


Edge of Floor
4½" FLOOR Smooth finish
Edge of Floor
Opening in Floor
Edge of Floor
Rod
Wire at intersections
End of floor rod
Hangers
Floor rods
Floor rod
End of floor rod
Rod
Edge of Floor and face of wall over
Line of Parapet wall over
Edge of Floor and face of wall over
Opening in Floor
Floor rods
These rods laid before main reinforcing rods
Opening
in Floor
FLOOR 4½" THICK Smooth finish
Edge of Floor and face of wall over
SCALE
Edge of Floor and wall over

DETAIL OF BREAK IN FLOOR OVER ROPE RACE BINS

Plan showing Reinforcement of Floors over Silos.
REINFORCED CONCRETE SILOS AT HULL.

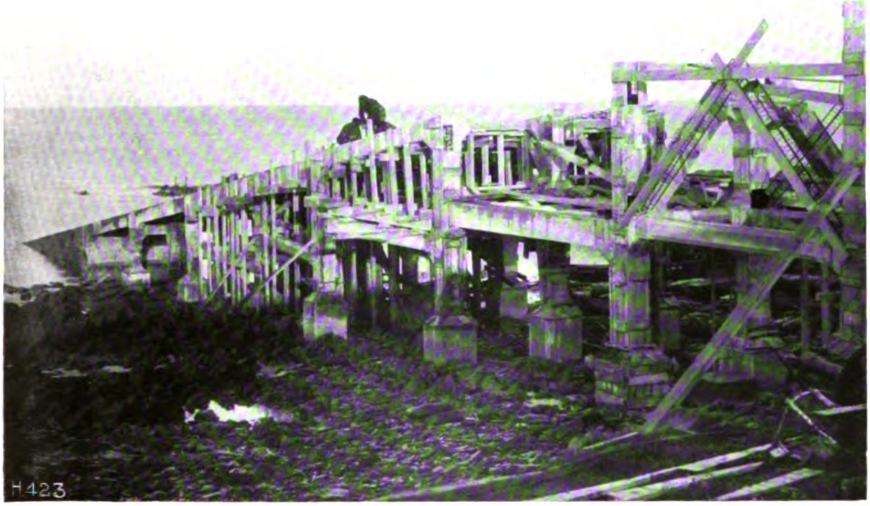
The building was put up in record time, and the contractors are to be congratulated on the efficient manner in which the work was carried out.

REINFORCED CONCRETE LIFEBOAT SLIPWAY AT ACKERGILL.

An interesting example of reinforced concrete construction, further illustrating the uses to which this material may be applied with advantage and economy, is to be seen in the new lifeboat slipway, recently constructed for the Royal National Lifeboat Institution, at their Ackergill Station, near Wick, in the north of Scotland.

Until recently lifeboat slipways have been constructed of steel rolled sections or timber, but, recognising the advantages of reinforced concrete with regard to maintenance and durability, it was decided to construct the new slipway in this material, and our illustrations show the work during erection and upon completion.

The slipway has a total length of 194 ft., the seaward toe being formed of mass concrete, and the remainder of reinforced concrete, supported on columns spaced about 20 ft. apart. At the upper end, for a length of 58 ft., and carried on three rows of columns, there is a platform 5 in. thick and 16 ft. wide, which forms the berth for the lifeboat and hauling winch, the height above the shore end being about 16 ft. A drop keel of open decking is provided under boat platform at a height of about 10 ft. above shore level. The remaining portion of the slipway is laid with a gradient of 1 in 7 down to low-water level, and is constructed of open framework on two rows of columns, thus offering as little resistance as possible to the heavy seas encountered on this coast. It consists of longitudinal keelway beams in pairs, 20 in. deep by 12 in. wide, between which, at intervals, are rollers supporting the lifeboat keel. There are also longitudinal bilgeways and cross beams 11 in. deep by 8 in. wide, spaced 2 ft. 6 in. apart for the entire length of slipway, the whole surface being designed to resist the heavy shocks which may be encountered by any member from the impact of the lifeboat in rough seas.



Side view during construction.
REINFORCED CONCRETE LIFEBOAT SLIPWAY AT ACKERGILL.

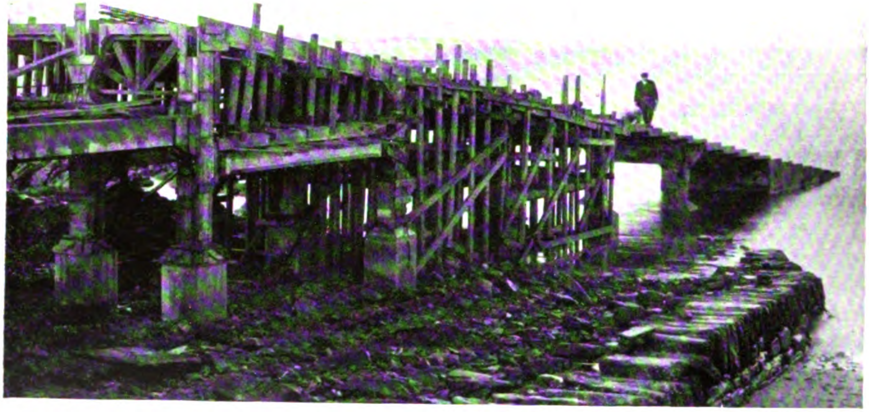
On one side of the slipway there is a projecting stepped platform 4½ in. thick, with grooved surface to provide foothold, and carried on cantilever brackets from the face of the columns.

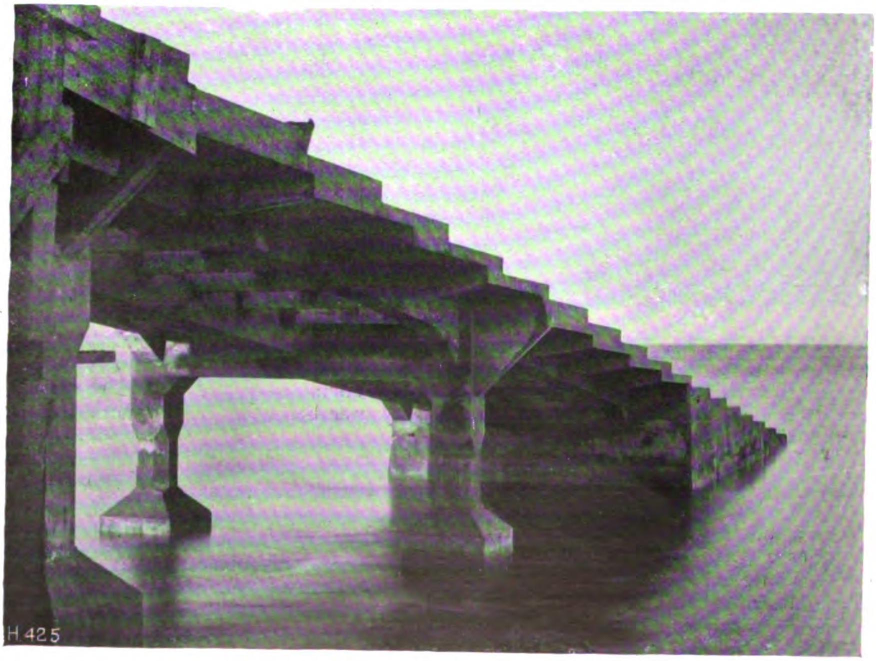
The columns supporting the structure are of octagonal section 14 in. in diameter, with bases 2 ft. 6 in. square taken down 2 ft. into the solid rock, of which the foreshore is composed, and additional anchorage was secured by carrying down the vertical bars of the reinforcement to a further depth of 18 in. into holes bored in the rock and afterwards grouted in with neat cement.

The columns and all bracings were reinforced with steel spiralling in addition to longitudinal bars, and full advantage was taken of continuity in determining the section of beams and girders.

The reinforced concrete details were prepared by the Considère Construction Co., Ltd., of 5 Victoria Street, S.W., from the designs of Mr. W. T. Douglass, M.Inst.C.E.,

View showing arrangement of Temporary Shuttering to 3 spans.





View of Mass Concrete Toe, with two lower spans of Reinforced Concrete work completed.

REINFORCED CONCRETE LIFEBOAT SLIPWAY AT ACKERGILL.

of 15 Victoria Street, Westminster, Engineer to the Royal National Lifeboat Institution.

The execution of the work entailed considerable difficulty and called for extreme care, owing to the heavy seas encountered during construction, and was satisfactorily carried out by Mr. E. R. Lester, of Plymouth, licensed contractor for the Considère System.

A similar slipway on the same system is at present in course of construction at Moelfre, Anglesey.

FLOORING AT THE EXTENSION TO SHEFFIELD ROYAL INFIRMARY.

THE illustrations we present show the new extension to Sheffield Royal Infirmary, where the floors throughout are being laid by the Armoured Tubular Flooring Co. upon their patented system, to the specification of Messrs. Gibbs & Flockton, architects.

These views show the magnitude of the building, which contains over 4,000 sq. yds. of Armoured Tubular flooring, more than one-half of this area being of clear span of 26 ft. in wards and flat roofs over same, these spans necessitating reinforced concrete joists of the unusual length of 28 ft.

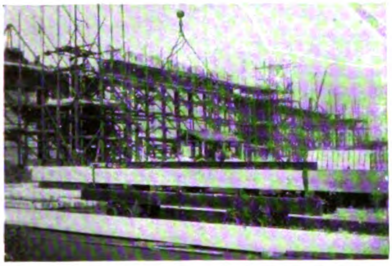


FIG 1. SHOWING JOISTS IN TRANSIT FROM WORKS TO BUILDING.

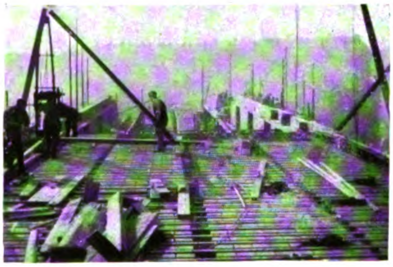


FIG. 2. SHOWING JOISTS LAID BEFORE APPLICATION OF TOP LAYER OF CONCRETE.

The joists and all units were manufactured on site by temporary plant and machines, in accordance with this patented system, and are shown in *Fig. 1* in transit from works to building, and in *Fig. 2* as they appear when laid with spacing-concrete tubes before the application of the top layer of concrete.

The nominal working load upon 26 ft. span ward floors may be taken at ½ cwt. per sq. ft. *Fig.* 3 shows test upon sample span of 3 joists loaded in accordance with architect's requirements to 3 cwt. per sq. ft., which gave a minimum of 1 th span deflection with entire absence of fracture in concrete, whilst completed floors tested to 2½ times their working load gave deflections of $\frac{1}{4000}$ part of span, this disappearing entirely on the removal of load.

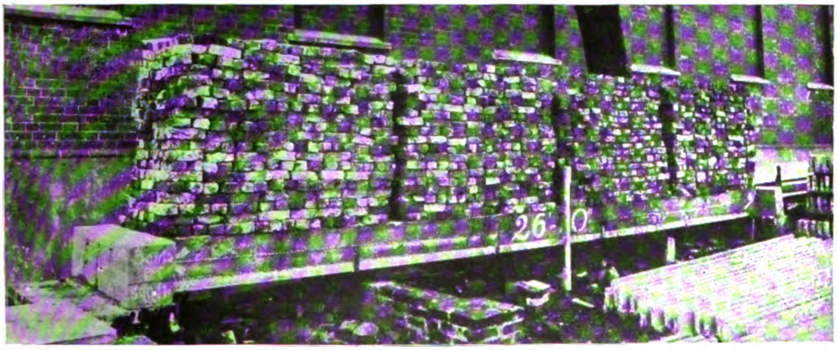


FIG. 3. TEST ON SAMPLE SPAN OF THREE JOISTS.

The many advantages of this system, and more particularly the unbroken soffit possible on wide spans, make it specially serviceable for hospitals and schools, and in buildings of the latter type, spans of 26 ft. 6 in. are being completed in Birmingham, whilst on the Continent spans of 30 ft. have been constructed with entire success.

NEW BOTTLING STORE IN REINFORCED CONCRETE FOR THE DARTFORD BREWERY.

Reinforced concrete has lately been very extensively applied to brewery work, and the accompanying illustrations of the new bottling store which has recently been completed for the Dartford Brewery, on the Coignet system of reinforced concrete, show another application of this method of construction.

The architect for the work was Mr. A. J. Style, F.R.I.B.A., and the contract was carried out by Messrs. William F. Blay, Ltd., of Dartford, licensees of the Coignet system.

The building is composed of a ground floor or cellar to receive casks. The first floor is used as a bottling store and is fitted with machinery, as shown in the illustration on this page.

New Bottling Store for the Dartford Brewery.

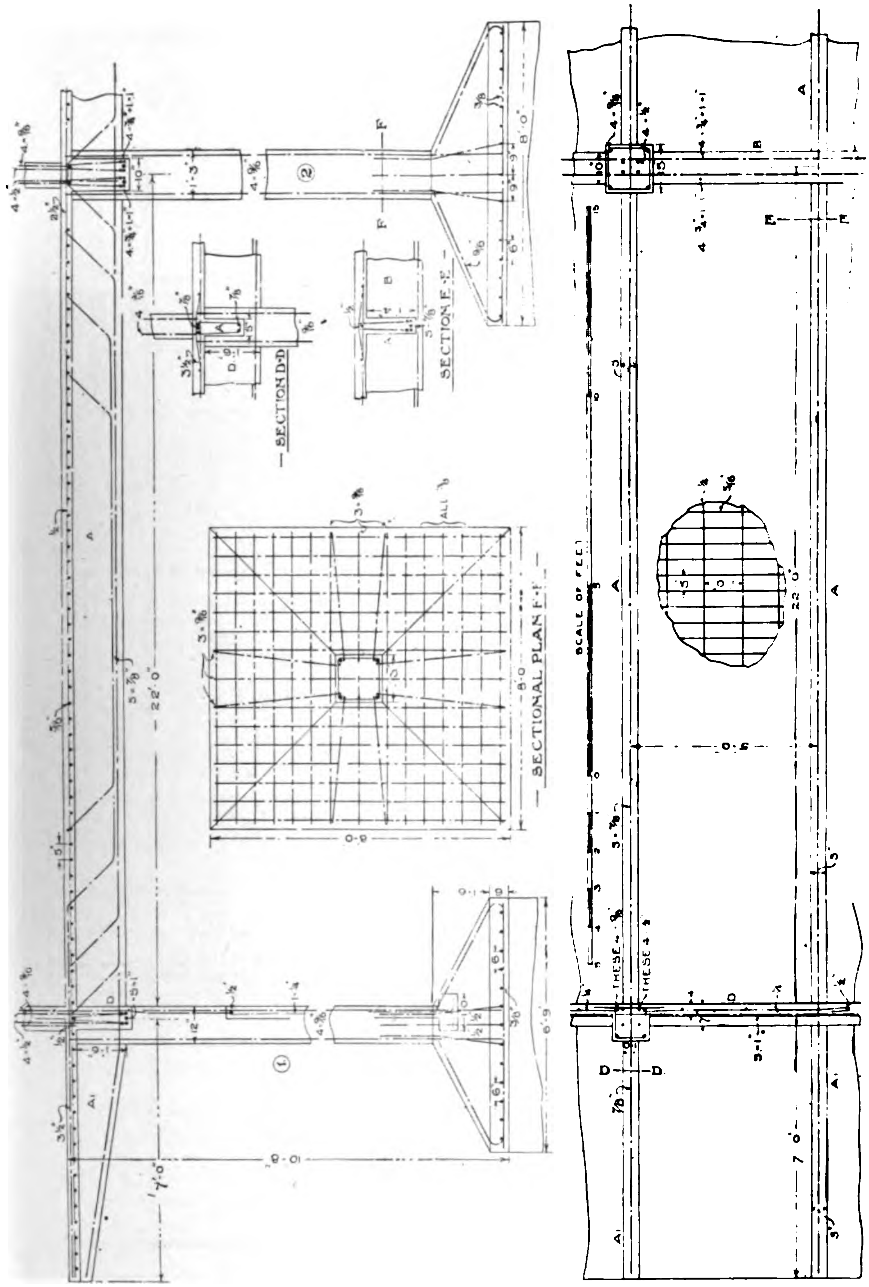
The building is covered by a flat roof containing four openings with lantern lights.

The general dimensions of the building are approximately 75 ft. by 45 ft., and the height, measured from the floor of the cellar to the top of the roof, is approximately 19 ft.

A noticeable feature of this bottling store is that the walls are also made in reinforced concrete 4 in. thick.

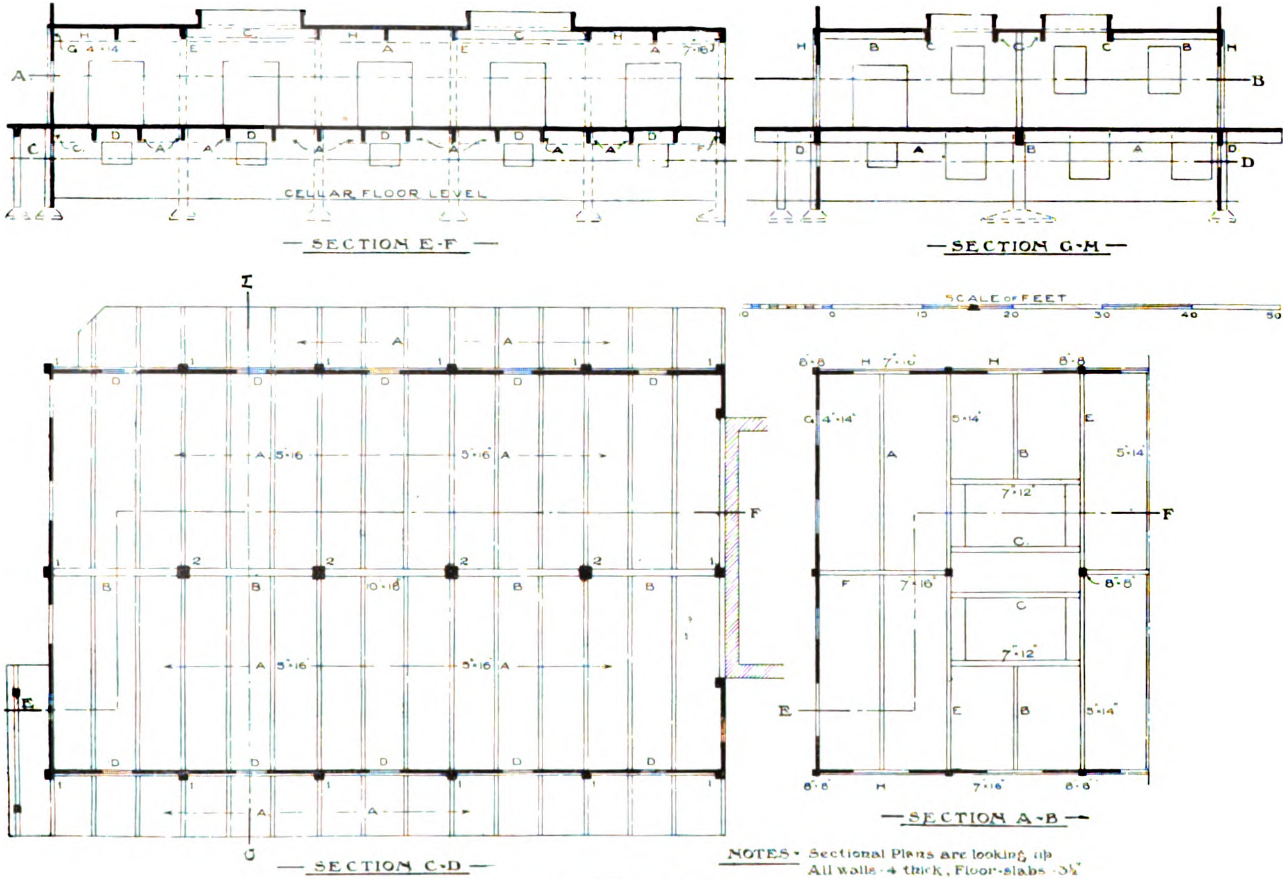
A cantilevered loading platform has been provided for, and this is illustrated on page 137.

The principal reason for the adoption of reinforced concrete for this work was the question of economy and durability.



General details.

New Bottling Store for the Dartford Brewery.

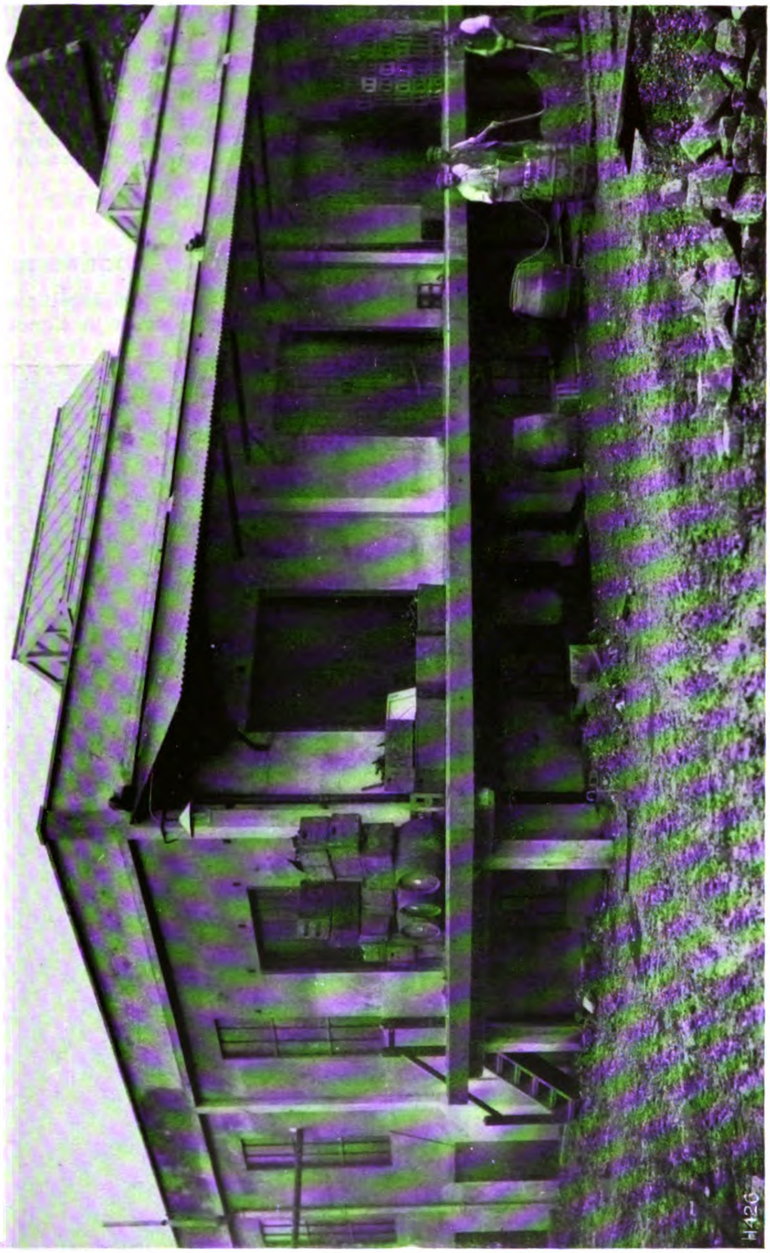


NOTES: Sectional Plans are looking up
All walls 4" thick, Floor-slabs 3½"

General Plans and Sections.

New Bottling Store for the Dartford Brewery.

The beams throughout the building were made according to the Coignet system of "equal resistance beams." According to this method the tension bars, generally seven in number, are gradually bent up at an angle of 45° and hooked over a longitudinal top bar. In this manner the bent portions are made to resist the shearing efforts, and these shear members are spaced closer towards the points of support.



Loading Platform.

New Bottling Store for the Dartford Brewery.

On page 136 we show plans and sections of the building, and on page 135 we give some details of the work.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

A REINFORCED CONCRETE CONDUIT AT WOOLWICH.

THE accompanying illustrations show a reinforced concrete conduit that has been recently constructed at Woolwich, and which is the first conduit in London district to

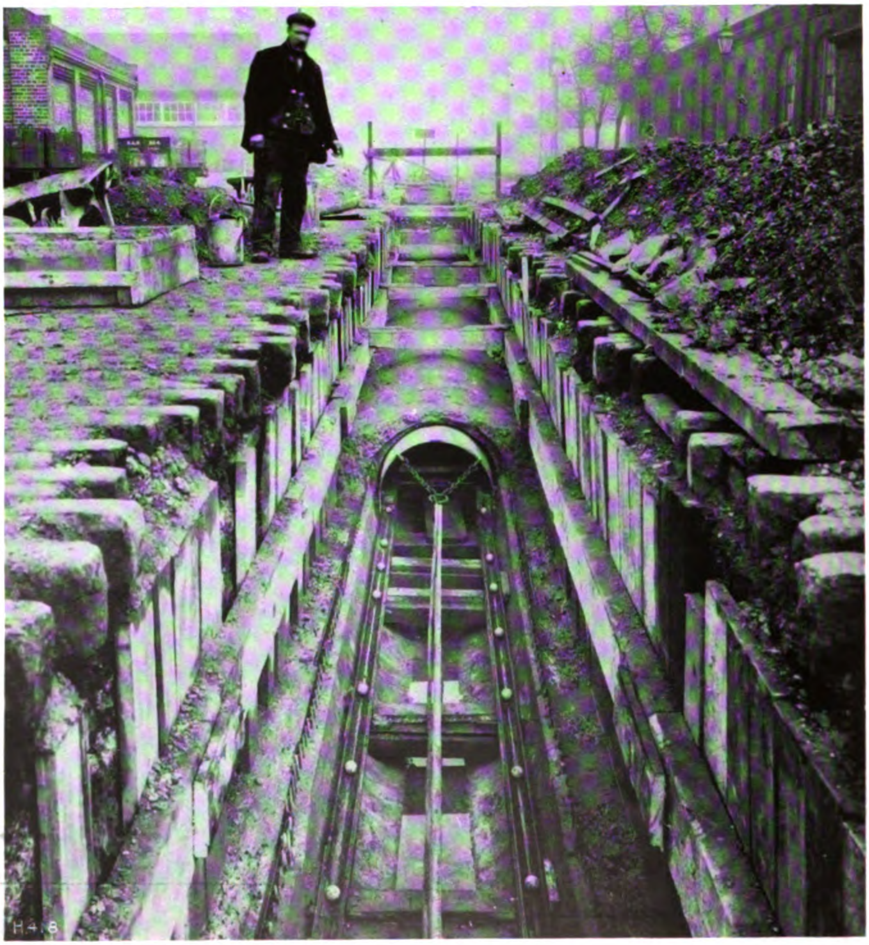


Fig. 1. Centres collapsed ready for pulling forward.
REINFORCED CONCRETE CONDUIT AT WOOLWICH.

be constructed on which the Blaw system of collapsible-steel centering has been used. *Fig.* 2 shows the section of same, whilst *Figs.* 1 and 3 give illustrations of the centering in use.

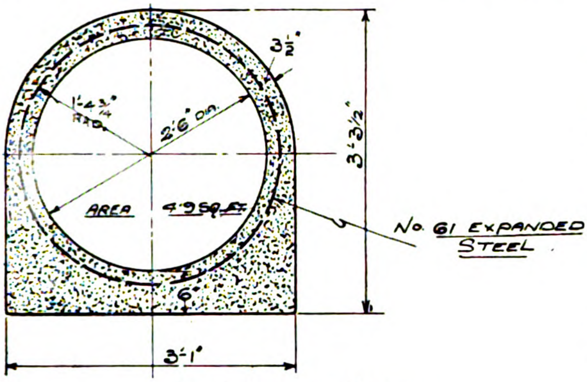


FIG. 2. SECTION OF CONDUIT.

The centres were half round and 2 ft. 6 in. diameter. The operation for constructing the invert was to set up the centres on a dish of concrete, and then concrete up to the springing line. As soon as this was set the centres were reversed and set up on timbers for concreting the crown.

About 20 ft. of centering was concreted at a time, and as soon as it was set the centres were collapsed and pulled forward on the angle irons, as shown in the illustration. A corresponding angle iron is placed on the centre, and the rolling forward is carried out by means of balls $1\frac{1}{8}$ in. diameter. They were found to pull forward very freely, and the surface of the concrete was particularly smooth.

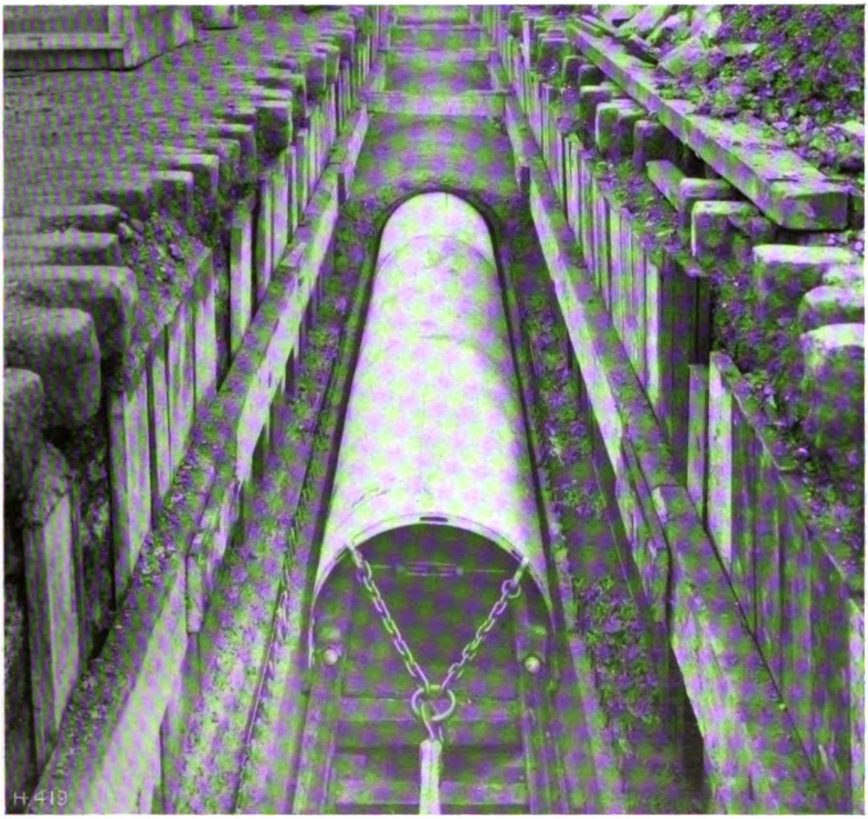
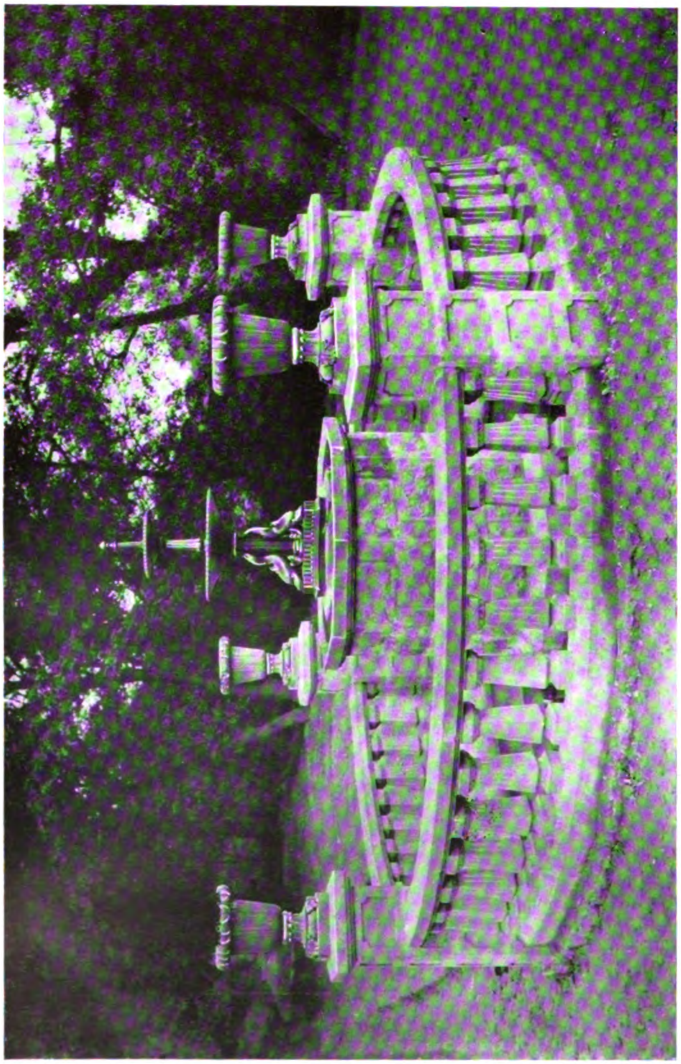


Fig. 3. Centres being pulled forward to next section.

REINFORCED CONCRETE CONDUIT AT WOOLWICH.

An interesting feature is the low cost of the centering which was leased for the contract, the cost of centering per foot of conduit only amounting to about 6d.

We may remark here that this centering is being used exclusively on the Concrete Collector for the Cairo Drainage Scheme, and on many other important works in this country and abroad.



Reinforced Concrete Fountain in North Wales.

A REINFORCED CONCRETE FOUNTAIN.

The fountain at Caergwrle Spa, North Wales, of which we show an illustration, is another example of the use of reinforced concrete for ornamental purposes.

This fountain is about 15 ft. in diameter, the walls and bed being made *in situ* of reinforced concrete, in which expanded metal was used.

The central pillar supports a concrete basin, which carries the brass fountain.

The basin is surrounded by a balustrade. The base, capping, and balustrades were made in Liverpool, and were carted to the site.

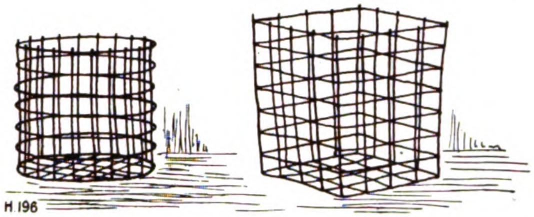
This fountain was erected by Mr. John S. Rigby, F.C.S., of 26 Bagot Street, Liverpool, and has given entire satisfaction.

HOW TO MAKE CONCRETE POTTERY.

Few people realise that anything of an artistic nature can be made from Portland cement, says a writer in the *Manchester Weekly Times*, who has followed the Portland cement industry for a great many years. Most of us are used to looking on this material as fit only for heavy construction work, such as foundations for buildings, bridge abutments, piers, &c. It is not remarkable, then, that the layman does not know that cement, if properly used, can be made to compare more than favourably with ornaments made from other and much more expensive materials.

Portland cement mortar, of which cement pottery is made, is composed of a mixture of sand or marble dust and pure Portland cement mixed together in various proportions. This mixture is wet down with water, and then, by turning over and trowelling, is made into a plastic mass called cement mortar. It is next to impossible to model in this material, for the reason that unless it is placed in a mould, or a form is used to hold it in shape while in its plastic state, it will fall down. The first step then in cement pottery work is to make the form, either by making wire frames on which to build up the cement mortar, or by making wooden or plaster moulds.

The use of wire forms, as illustrated, is the simpler when there are but one or two of the same shape of articles to be made. When a quantity of one kind is to be made it pays well to spend some time in making a wooden or plaster piece mould, as it can be used over and over again, whereas when wire forms are used a new form has to be made for each article, whether of the same shape or not.

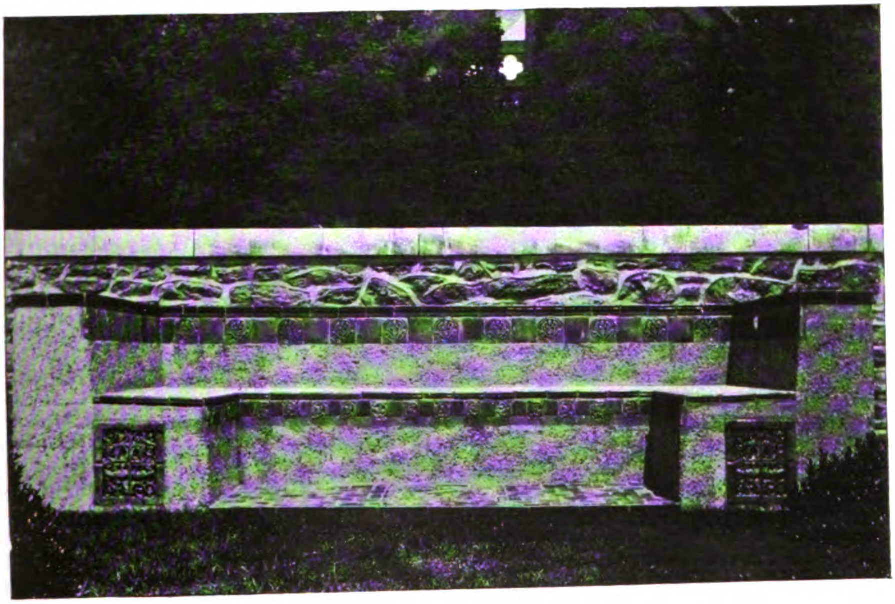


Wire Forms for making Concrete Pottery.

CONCRETE GARDEN BENCH.

The garden bench of which we give an illustration is very simple in outline and treatment, and is an attractive example of the utility of concrete for garden work of this character.

The bench is 12 ft. long and 5 ft. wide, and, as will be seen in the photograph, the concrete has a rough surface except on the seat, on which the face is smooth. The concrete is composed of Portland cement, coarse, sharp sand, containing some gravel, and cinders, mixed in the proportion of 1, 2½, and 5. The flooring is made of tiles, and tiles are also carried in a band along the back of the seat. The tiles are in artistic shades of red and blue-green, and are especially appropriate and pleasing when combined with this class of concrete work.



Concrete Garden Bench.

We are indebted to our contemporary, *The Cement Age*, for the illustration.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the past year.

Chemistry for Builders. The Chemistry and Physics of Building Materials. By Alan E. Munby.

Published by Constable & Co., London, 1909. Six Shillings net.

Contents.—Natural Laws and Scientific Investigations.—Measurements and the Properties of Matter.—The Air and Combustion.—Heat: its Nature and Measurement.—Heat and its effects on Materials.—Chemical Signs and Calculators.—Water and its Impurities.—Sulphur and the Nature of Acids and Bases.—Coal and its Products.—Outlines of Geology.—The Constituents of Stones, Clays, and Cementing Materials. — Classification of Stones.—The Examination and Testing of Stones.—Brick and other Clays.—Clays (*continued*), Kiln Reactions, and the Properties of Burnt Clays.—Plasters and Limes.—Cements.—Theories upon the Setting of Plasters and Hydraulic Materials.—Artificial Stone: Oxychloride Cement; Asphalte.—The Metals: their General Properties and Occurrence.—Iron and Steel.—Other Metals and Alloys.—Tests upon and Strength of the Metals.—Timber.—Paints: their Solid Ingredients, Bases, Pigments, and Driers.

The intention of this book is to instruct persons interested in the use of building materials but having no scientific knowledge in the chemical and physical properties of those materials. With this object, the first part of the book is devoted to an outline of the sciences in question, and the second to their application. It may well be questioned whether such a plan is the best to be adopted. To write an elementary treatise on chemistry, physics, and geology in the space of 104 pages of rather large type is an enterprise foredoomed to failure, the information given being necessarily very superficial, and it may be doubted whether an engineer or builder, unaccustomed to the use of chemical equations, could derive any benefit from so brief an outline as is here given.

We are glad to be able to speak in much more favourable terms of the second part of the book. Building materials are dealt with in the order named: stones, plasters, limes and cements, metals, timber, and paints. The information as to the nature and properties of each material is concisely given, and we have noted very few minor inaccuracies. The section dealing with Portland and other cements is particularly interesting, and includes a clear statement of some of the rival modern views of the nature of the setting process. Some references to the changes which cement undergoes during storage would have added to the usefulness of this section. It is highly desirable that users of cement should have some idea of the chemical character of the material with which they have to deal, and the present work may be recommended for this purpose. The chapters dealing with paints also contain much that is of interest.

We would venture to suggest that the book would have been improved by the omission of Part I. altogether, referring the reader to other easily accessible sources of information, the space thus saved being utilised for a fuller presentation of some points which it has been necessary to treat rather hurriedly.

Much useful information has been brought together in a small compass in the second part of the work that should prove helpful to many persons engaged in constructional work, and for that part alone the volume may be commended.

Coast Erosion and Foreshore Protection. By John S. Owens and Gerald O. Case, M.D., M.Inst.C.E., F.R.G.S.

Published by The St. Bride's Press, Ltd., London, 1908. Seven Shillings and Sixpence net.

This is a most useful booklet, and has appeared at a most appropriate moment, when serious consideration is being given to the protection of our coasts from encroachment by the sea.

The facts are concisely presented; the type is good, and even if the advocacy of reinforced concrete is somewhat *ex parte*, having regard to the well-known views of the authors, the book certainly should have its place in the library of every local authority having to deal with foreshore questions.

Tables for Reinforced Concrete Work.

Messrs. Julius Springer, Berlin, have published at the price of marks 0.60 (about

6d.), a handy folding sheet, compiled by Engineer G. Funke, Leipzig, entitled "Tabellen für die Berechnung von Eisenbetonkonstruktionen," and giving factors and coefficients for calculating reinforced concrete work. The figures in the tables are in accordance with the Ministerial conditions of May 24th, 1907, and with those of the German "Beton-verein."

The Theory and Design of Structures:—*A Textbook for the use of Students, Draughtsmen and Engineers engaged in Constructional Work.* **By Ewart S. Andrews, B.Sc. Eng. (Lond.),** *Lecturer at the Goldsmith College, New Cross.*

Published by Chapman & Hall, Ltd., London, 1909. Nine Shillings.

Contents: Stress, Strain and Elasticity.—Principles of Design; Working Stresses, etc.; Wind Pressure.—Forces, Areas and Moments.—Riveted Joints and Connections.—Bending Moments and Shearing Forces in Beams.—Stresses in Beams.—Bending Moments and Shearing Forces for Rolling Loads.—Deflections of Beams.—Fixed and Continuous Beams.—Distribution of Shearing Stresses in Beams.—Framed Structures.—Columns, Stanchions and Struts. — Suspension Bridges and Arches.—Masonry Structures.—Reinforced Concrete and Similar Structures.—Design of Steelwork for Buildings, etc.—Design of Roofs.—Design of Bridges and Girders.—Exercises.—Tables of Properties of British Standard Sections.

In the preface the author states half apologetically his object in "Adding to the list—already long—of textbooks dealing with engineering science." Certainly the subject of the Theory of Structures has received rather more than its due amount of literature; the reason no doubt being that each lecturer on the subject has his own ideas as to the best method of imparting such knowledge to his students and the proper sequence in which it should be presented to them. The latter consideration is a very important one—like the chef's duty in preparing a menu—in order that the student's brain may properly assimilate its mental food.

In the case of this textbook the author may certainly be excused "for adding to the list." He has achieved his object in providing at a reasonable cost a clearly written textbook, covering almost too sufficiently wide a ground, avoiding all unnecessary aid of the calculus and higher mathematics where the demonstration may be made by simpler means. Another feature of the book is that the graphical and analytical methods of dealing with bending moments and stresses are made to go hand in hand; this is quite as it should be. Too often the two methods are kept severely apart, so that instead of one being taught as complementary to the other, they, and more especially the graphical method, lose much of their coherence when their partnership is dissolved. As the engineer gains in experience he will probably learn to rely less and less on the graphical method, as the other is of greater accuracy and the results can be obtained far more rapidly. At the same time, the graphical system enables him to form, as it were, a mental vision of the mathematical calculations. Occasions may also arise where the engineer in his practice is called upon to design some structure outside the ordinary course; in that case the graphical method is of great assistance as a guide and a check upon his calculations.

The sequence in which the author deals with his subject may be gathered from the Chapter headings. That the relationship between stresses and strains is a matter of cause and effect is undoubtedly starting the student along the right path. Until recently strains played a comparatively unimportant part, but since the introduction of reinforced concrete they have, so to speak, come into more daily use, forming as they do the basis from which the formulæ for composite beams are derived. In Chapter II. the author rightly condemns the "Factor of Safety" heresy in dealing with working stresses. Chapters I. to X., also Chapter XII., which might well have preceded Chapter XI., would come more appropriately under such a title as "The Strength and Resistance of Materials." When the author at Chapter XI. reaches what to the majority of students is the most fascinating portion, viz., "Framed Structures," he appears to pass very rapidly along his subject at this stage. Chapter XV. deals sufficiently adequately, as far as the student is concerned, with the theory of reinforced beams and columns. If he thoroughly grasps what the author calls the "Straight-line no-tension method" the rest should come easily to him.

It seems almost unfortunate that the author should have included "And Design" in the title of his book; the remainder of his book is apparently included to justify this much of the title. The various systems of reinforced concrete might well be presented to the student in the form of a collection of handbooks issued by those firms. Design is rather to be obtained by actual practice. A few months in the drawing office of a constructional steel contractor may not give to the young engineer much experience in the theory of structures, but will more than make up for it in the matter of design. The weak part of the book is unfortunately what its title implies, viz., the theory of structures, especially framed structures. What might more appropriately come under the heading of "The Strength and Resistance of Materials" is the best portion of the work. Undoubtedly the book would be vastly improved by sacrificing the "Design" idea and devoting the space to a fuller consideration of the framed structure pure and simple. The last half of the book leaves an impression that the author has far more to say than there is space within which to express it.

Practical Building Construction :—*A handbook for Students preparing for the Examinations of the Science and Art Department, the Royal Institute of British Architects, the Surveyors' Institution, etc.* **By John Parnell Allen,** *Formerly Lecturer on Building Construction at the Armstrong College of Science, Newcastle-on-Tyne.*

ublished by Crosby. Lockwood & Son, London, 1909.
Seven Shillings and Sixpence.

Contents: Bricks and their Composition.—Brick Bond and its Applications.—Brick Reveals, Arches and Pointing.—Damp and its Prevention.—Building Stones and Stone Walling.—Stone Dressings, Joints and Stairs.—Wood for Building Purposes. — Wood Floors. — Partitions. — Roofs.—Iron and Steel.—Rivets and Riveting.—Iron Roofs.—Coverings for Roofs.—Fireproof Floors, Partitions and Ferro-Concrete.—Joints and Mouldings in Joinery.—Doors: Their Finishings and Fastenings. — Windows and Window Finishings.—Wooden Stairs.—Skylights and Lanterns.—Plasterings, Painting and Glazing. — Centering, Foundations, Shoring, Scaffolding, Sewers.—Miscellaneous Materials.—Stresses.—Calculation of Strains. — Sanitation. — Fireplaces. — Weights, Strengths, Quantities and Prices. —Tools Used by Various Trades.

That Mr. Allen's book has now reached a fifth edition evidently testifies to the fact that it satisfies a want. The book may be described as an abridged encyclopædia on Building Construction. So much so that each chapter may be said to contain sufficient material on which a book equally as large might be written. The striking feature of this book is the number of illustrations and definitions of technical terms it contains. Covering such a vast field, perhaps it would be advisable to confine this review to that part which deals with reinforced concrete and constructional steelwork. Chapter XV. devotes three pages to "Ferroconcrete," containing a short description of what it is, "Materials," "Tests for Cements," "Aggregate," "Mixing," and "Construction," followed by some illustrations of various systems.

As regards constructional steelwork, Chapter XXIV. is devoted to "Stresses." Some of the definitions here given are decidedly peculiar—*e.g.*, "*The bending moment* indicates the extreme weight, or maximum stress, applied to a member to make it collapse," while the *moment of resistance* denotes the opposite—*i.e.*, "the strength of a member short of collapse."

Apart from the fact that a bending moment denotes any variable amount, it is neither a weight nor a stress. So, too, in the following chapter, "Calculation of Strains," the word "Strains" is employed in an erroneous sense; in strict engineering parlance there is no such thing as "A twelve tons strain." As the book is intended for students these two chapters might with advantage have formed part of the revision of this new edition.

It were better for the student, if he intends to make a further study of this branch, to approach it with an open mind, rather than have to unlearn its elementary principles. For this reason especial care should be taken in such a book as this, written, as it is, in order to "lead many students to seek a more complete mastery of the particular subjects to which they may find it best to give special attention." With the above reservation, it may be said that the book should offer, especially as regards the copiousness of the illustrations, a sufficient incentive to achieve this object.

A Concise Treatise on Reinforced Concrete. *A Companion to "The Reinforced Concrete Manual."* **By Chas. F. Marsh, M.Inst.C.E., M.Am.Soc.E., M.Inst.M.E.**

Published by Constable & Co., Ltd., London, 1909.
Seven Shillings and Sixpence net.

Contents: Properties.—Behaviour under Loading.—Necessary Assumptions for Purposes of Calculation.—Methods of Calculation. —Methods of Reinforcement.

Two of the best known and best received books on the subject of reinforced concrete which have been published in the English language are "Reinforced Concrete" and the "Manual of Reinforced Concrete," of which Mr. Chas. F. Marsh and Mr. William Dunn, F.R.I.B.A., are the joint authors. Mr. Marsh has now written a companion volume to the manual, which has just been published. The large treatise deals more fully with every aspect of the subject than does this work, but the reason expressed in the preface for its publication is that the publicity given to the use of the material since the first issue of the larger work has made it possible to treat the subject in a considerably more condensed manner than was justified a few years ago, since details of construction and lengthy descriptions of experiments no longer possess the special interest they had in the immediate past. This book should in part meet the demand which there is for a concise and handy volume, and certainly the author has managed to deal very clearly and very comprehensively with a subject which it is rather difficult to express shortly. This work deals mostly with theory, with some short references to experimental data, and a concluding chapter on some methods of reinforcing various structural members. There are points in theory upon which most specialists in this form of construction differ, but Mr. Marsh has very clearly stated the reasoning upon which his conclusions are based and the limiting factors of the problem, though we are inclined to think that some of the factors which he dismisses as of minor importance deserve more consideration and do affect the design considerably. As an introductory work, however, the book is most praiseworthy. Any student thoroughly digesting this work will be led to investigate the subject further. We think that a warning needs to be uttered in view of the increasing number of text-books on the subject in respect to the importance of reinforced concrete work being designed by those who have specialised in the subject. The time is not yet ripe for the general practitioner to attempt to deal with the subject; even specialists find many awkward problems, and know the advantages of experience, and if they find a subject sometimes intricate and needful of great care to avoid grave errors, entailing perhaps danger to life, it proves that it would be dangerous for architects and engineers generally to undertake to design such work without specialising, to say nothing of the loss that may be occasioned and extravagant employment of materials.

We hope that this first edition will meet with a ready sale, and that in succeeding editions the standard notation of the Concrete Institute will be adopted.

The Theory of Structures. By R. J. Woods, M.E., M.Inst.C.E., *Fellow and formerly Assistant Professor of Engineering, Royal Indian Engineering College, Cooper's Hill.*

Published by Edward Arnold, London, 1909. Ten Shillings and Sixpence net.

Contents: Compound Stresses.—Principal Stresses.—Earth Pressure.—Stresses due to Eccentric Loads.—Working Stresses and Cross Sectional Areas.—Stresses in Girders with Parallel Chords by Method of Co-efficients.—Girders with Parallel Chords.—General Method.—Parabolic Girders.—Curved Girders not Parabolic.—Wind Pressure.—Portal Bracing.—High Steel Trestles.—Continuous Girders.—Cantilever Girders.—Suspension and Stiffening Girders.—Design of Riveted Joints.—Plate Girders.—Columns and Struts.—Arched Ribs and Braced Arches.—Reinforced Concrete.

This volume, although perfectly complete in itself, is a continuation of the author's previous work, entitled "The Strength and Elasticity of Structural Members."

A large portion of the book is devoted to the working out of practical examples, which makes it particularly useful to students, and also as a reference book for engineers and architects.

The last chapter only is devoted to reinforced concrete, and we regret that the author did not devote more space to this important subject. This chapter gives the advantages of reinforced concrete, and also an idea of the many different kinds of modern buildings in which it can be used with success. It deals at length with the crushing strength and the safe compression of concrete in beams and columns, and with the adhesion of concrete to steel and the shearing force in the webs of reinforced concrete beams. The working stresses in reinforced concrete are dealt with very explicitly, and examples are given of the methods of calculating the many forms of reinforced concrete with the various formulæ for same.

Concrete Steel Construction. Part I.—Buildings. *A Practical Treatise for the Constructor and those commercially engaged in the industry.* By C. A. P. Turner, M.Am.Soc.C.E.

Published by the Farnham Printing & Publishing Co., Minneapolis. Twenty Dollars.

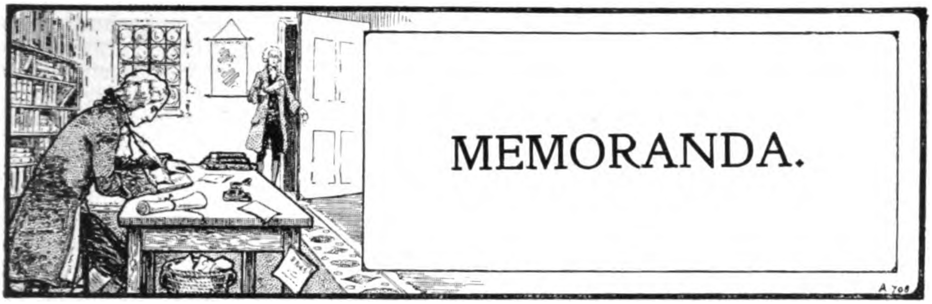
Contents: Materials.—General Types of Concrete Steel Construction.—Computation.—Tests of Slabs and Floors.—Discussion of Theories and Elastic Properties.—Columns.—General Principles Governing Economic Design.—Systems of Reinforced Concrete.—Foundations.—Working at Various Temperatures.—Bending Steel.—Protection of Steel and Provision for Plumbing and Plastering.—Fire Protection.—Floor Finish.—Responsibility of the Engineer and Contractor.—Rapidity of Construction.—Centering.—Cost of Work.—Permanence of Concrete Construction.—Requirements of Different Classes of Buildings.—Artistic and Commercially Practical Concrete Surface Finishes.—Casualties and Accidents.

Appendix: Suggestions for a Concrete Constructor's Library.—Shipment of Cement.—Patents and Patent Laws.

This book is written from the contracting engineer's point of view, and consequently differs very materially from the usual treatise on reinforced concrete. Practical considerations in construction are given the preference over theoretical formulæ. The writer evidently prides himself on what he as an American would probably term his "good horse sense"; and it may be said that his book contains an ample amount of this commodity. As against this must be place a detracting feature, viz., that the book is written mainly with a view to extolling the author's own patented method of construction; in fact, it may be termed a glorified catalogue of the "Mushroom" system of reinforced concrete floors. No doubt this system is in every way an excellent one; in fact, so much so in the author's opinion that the other methods receive at his hands but a scant amount of courtesy. Briefly put, the author divides floor construction into four types, viz.: (1) main beams between columns carrying intermediate bearer beams with slabs of short span; (2) main beams in one direction only with long span slabs; (3) main beams in two directions with rectangular slabs supported on each of its four sides; (4) slab floor only carried at the column supports, so that the slab rests on four supports at each corner of the slab. Type 4 includes what the author calls his "Mushroom" system, the distinctive features of which are special reinforcement of the column caps, somewhat in the form of a mushroom head, together with the floor reinforcing bars running in four directions, *i.e.*, two at right angles to one another in the direction of the lines of the columns and two crossing the rectangular floor slab diagonally, similar, in fact, to the arch ribs of a groined ceiling. In this way, by making the caps of the columns sufficiently large, the intervening floor space is covered with a network of rods running longitudinally, transversely and diagonally with the plan of the floor. The floor thus consists of floor slabs supported at their four corners and continuous over the points of support. The calculations for such slabs are somewhat complicated, but the author shows how the coefficient for the safe bending moment may be taken at a low figure. He also checks this by a large number of actual tests, showing that they agree closely with the calculated deflections. Deflections, except in the hands of a thoroughly competent engineer, are dangerous things to argue with, as they vary according to how the beam is loaded, and also in what manner the beam is supported; under uniform conditions, as the author shows, deflections may be made to represent something tangible, instead of, as in the majority of cases, something that has been obtained with much trouble and affords little information in regard to the internal stresses that cause the deflections. The author himself seems to arrive at an erroneous conclusion in regard to the effect of deflections, for he says: "The most careful measurement placing standards in adjacent panels fails to reveal any negative deflection in the adjacent panels under loads of one and two hundred tons in the test of a single panel. Thus it is evident that there can be very little eccentric stress transmitted to the column." It may be rather that it is *on account of* the eccentric stresses in the column that the negative moment is not transmitted to the adjacent panels, but is absorbed by the columns.

The author very rightly condemns the practice of testing the floors before the concrete has been given time to become properly cured; such tests only weaken the structure and indicate rather what may be placed on the floors during the construction of the building than the ultimate strength of the floors. A chapter deals with the treatment of concrete made during extremes both high and low of temperatures; this, together with a chapter dealing with the cost of the work, is of more value to American than English contractors. An interesting chapter is that in which the author describes how the surface of concrete may be treated to give it an artistic finish; like most of the materials employed by engineers reinforced concrete is utilitarian rather than decorative, and attempts to make it of pleasing appearance deserve encouragement.

The book contains a great number of illustrations, chiefly showing work during construction; the author has also the courage to include some showing how buildings have collapsed owing to faulty designs.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Painting Concrete Houses.—In a recent number of *The Building News* the following two methods of painting concrete houses are given:

The first is to mix colouring ingredients with the cement which will present lasting qualities, and the second is to paint the exterior surfaces with some paint which will give somewhat similar results. The mixing of different coloured sands with the cement to get colour-schemes, and the adding of certain oxides to the mixture to intensify certain shades, are still in the experimental stage.

The difficulties in the way of applying colours to the exterior after the concrete house is finished are somewhat similar to those which apply to exterior painting of frame houses. The weather affects them and necessitates repainting at intervals. The use of lead and oil paints is not of lasting quality. The alkali of the cement has an affinity for linseed-oil, and in time the oil oxidises and causes the paint to peel off or dust. Experimenters have realised for years that the ideal paint for concrete houses must be something more than a thin film. It must be a composition that will penetrate the surface and fill the pores, so that firm adherence can be obtained. A paint composed of colour-pigments, with ground cement as the base, gives good results. The light chemical oils used are intended to dry out after performing their function of bonding the cement base to the concrete surface. The cement base thus becomes a part of the wall and holds its colour indefinitely.

When Nature, in the form of wind, rain, and sunshine has neutralised the alkalies of the cement it is much easier to paint the exterior structure and secure more durable results; consequently it is unwise to figure upon having concrete houses painted when finished. If this is intended the highest results cannot be expected. Old concrete houses that have stood exposed to the weather for a year or two are in much better condition for painting. The film of paint is waterproof and hence checks the process of neutralisation of the alkalies in the cement. If the house has had an opportunity to dry thoroughly the question of painting the exterior surface to get another colour can be considered with hope of success.

Warrington Bridge.—The Warrington Town Council have accepted the tender for this bridge, and have let the contract to Messrs. A. Thorne & Sons, of Westminster, the bridge to be constructed on the Considère system of reinforced concrete. The total number of tenders was twenty, and the two selected for final consideration were those of Messrs. Christiani & Nielsen, of Copenhagen, and the Considère Construction Co., the latter company being granted the award. The total cost of the new bridge, which is to be 80 ft. wide, will be £14,310, including training walls, and it will thus be one of the widest in England.

Tests of Reinforced Concrete Telephone Poles.—Mr. W. M. Bailey, in a paper read recently before the International Independent Telephone Association of America, described a very thorough test of a concrete pole made in Richmond, Ind., as follows:

"The pole was 30 ft. long and embedded 5 ft. in the ground. It was 7 in. square at the top and 12 in. at ground line, and was thoroughly braced so as to make it perfectly rigid. It was reinforced with four ⅝-in. twisted steel rods, having an elastic limit of from 50,000 to 80,000 lb. per sq. in., and thoroughly bound together with No. 9 binding wire. With a horizontal pull of 840 lb. at the top the deflection was 6 in.; with 1,780 lb., 17 in.; with 2,800 lb., 30 in. deflection, producing a slight cracking. The pole deflected 6 ft. before falling; the rods did not break, but the concrete crumbled and the rods bent over. A cedar pole of the same size deflected 11 in. with a pull of 840 lb.; 33 in. with a pull of 1,780 lb., and broke 3½ ft. from the ground line with a pull of 2,200 lb. A concrete pole can be built for very nearly the same cost as a first-class cedar pole can be furnished."

Concrete for Motor Car Houses.—A recent issue of *The Autocar* gives suggestions for the guidance of those who contemplate erecting a special building for the protection of their cars. Sketches of suitable houses are given; the building to be erected upon brick sleeper walls, having Portland cement concrete foundations. The floor is made of the same concrete, six inches thick, floated over with cement and sand. If a pit is required in the motor-house they recommend that it should be formed of 4½-in. brickwork in cement upon a 6-in. bed of cement concrete. The inner faces of the walls and the floor are to be rendered with a good coating of cement and sand.

Reinforced Concrete for Machine Shops.—Reinforced concrete seems likely to be found very advantageous in the construction of machine-shops. This material, as far as it concerns the machine-tool industry, was discussed at the recent Conference of the National Machine-Tool Builders' Association, on which occasion Mr. J. P. Perry, of New York, pointed out the importance of the load-carrying capacity of reinforced concrete structures in this connection. It was remarked that reinforced concrete buildings are noted for their strength and their ability to safely carry unexpected loads. Floors have been designed to carry 600 lb. per sq. ft., and have been subjected to 1,500 to 2,000 lb. live loads without the slightest indication of injury or increased deflection.

Reinforced Concrete Power House.—A separate unit type of reinforced concrete wall construction was used last year in building the power-house of a small hydro-electric plant at Newton Falls, Ohio. The pilasters are of monolithic concrete, while the walls between them are hollow and are built of inside and outside thin concrete slabs, which were set before the pilasters were poured, so as to be keyed into them. The slabs were reinforced with No. 28-gauge expanded metal and were made in sizes that could be handled conveniently. Their outer surfaces were corrugated by laying ⅝-in. round rods in parallel lines on the surface of the fresh concrete when the slabs were cast and pulling them out after the mixture had taken its initial set. These corrugations were designed to give a good bonding surface for the plaster coat which was applied to the walls after they had been erected. The slabs were allowed to cure and were then placed on edge in proper position. Vertical form boards were placed for the pilasters, extending beyond the surface for the monolithic work, so that the slabs rested against them. The inside faces of the pilasters were moulded against form boards placed in the air space between the wall slabs, and were wired to the outside forms after the pilaster reinforcement had been placed. The inside boards also acted as spaces to keep the slabs the proper distance apart. This distance varied somewhat, but 8 in. was the minimum.

New York Water Supply.—The new Kensico dam, to be built across the valley of the Bronx river, and forming part of the general scheme whereby it is proposed to deliver to New York city a daily quantity of not less than 500 million gallons of water, will be a masonry structure 1,830 ft. long, with a *maximum* height of 170 ft. above the existing river bed, with foundations extending to solid ledge rock 120 ft. or more below the surface at the deepest point. Very large masonry and concrete blocks, with ornamental stone facings on exposed portions, will be used. When completed the dam will form a storage reservoir holding 40,000 million gallons, or approximately two months' supply, the flow line being at 355 ft. above mean sea level. The *Engineering Record* states that the tenders for the work were opened on December 21, the lowest bid amounting to £1,590,600.

Concrete Dams.—A writer in *Cassier's Magazine*, on the subject of "Concrete Dams," says: "Among the important structural problems which the civil engineer is called upon to solve one of the most prominent, both by reason of cost and of consequence of its results, is the masonry dam. It has been assumed that a dam 'must be secure against sliding on its base or any plane within the body of the dam, against overturning, and against crushing of the material at any point and consequent opening of a seam at either face of the dam.' Compliance with these conditions has led to the design and construction of great masses of solid masonry, capable by their weight, and by the friction of their bases upon the foundation, of resisting any sliding action; and designed, as regards section, to compel the pressure to act at such a leverage as to be incapable of causing failure by overturning.

"The advent of concrete into general structural work, both in the plain and the reinforced forms, has directed attention to the special applicability of this material for the construction of dams, and with the consideration of concrete as a possible material there has naturally come also an appreciation of the immense advantage of a material which permits the control of the internal structure of the barrier.

"It might seem as if the greater simplicity of the massive dam should give it preference, at least in many instances, but, upon examination, the masonry dam is seen to be by no means the simple structure which it at first appears. The mass must be carefully computed and proportioned to prevent rupture or overturning at times of maximum flood. The heavy burden involves a correspondingly large and deep foundation, with all the concomitant difficulties encountered in the form of ground water, subterranean springs and percolation. The necessity for perfect union of base with foundation, both to prevent sliding and to avoid the penetration of water, tasks the ingenuity of engineer and constructor to the utmost.

"The adoption of concrete as the material for dam construction has enabled many of the former difficulties to be overcome or minimised. By substituting a hollow for a solid structure the weight is correspondingly reduced. This avoids the dangers of upward pressure, since any percolation into the interior cannot accumulate, but passes away gradually as it enters. Forces tending to cause failure by sliding or by overturning may be met by giving the structure such proportions that the resultant of all the forces due to any maximum head of water shall always pass well within the base—a matter readily accomplished with such a material as reinforced concrete."

The Society of Engineers.—The Society of Engineers will award a prize—designated "The Status Prize"—each year for the next four years (if papers of sufficient merit are received) for the best paper written by any person on the subject of "How to Improve the Status of Engineers and Engineering, with special reference to Consulting Engineers." The prize will consist of books and (or) instruments, of the value of three guineas, to be selected by the author of the essay gaining the award. The regulations governing this prize are as follows:—

> The essay shall be written in the third person, shall contain not fewer than 4,000 nor more than 6,000 words, and shall be typed on one side only of foolscap paper, the distance between the lines being ½ in. or more.
>
> All essays submitted in competition for this prize and the copyright therein shall become the property of the Society, but the donor also shall have the right of publishing such essays or any part thereof.
>
> The Council of the Society may, at their discretion, permit the publication of any essay by its author, on such conditions as they may think fit to require.
>
> The premiated essay shall be read and discussed at a meeting of the Society, the reading being done by the author if possible, and such essay shall be published in the usual manner in the Society's Journal, the author being entitled to receive 50 copies of his paper upon publication thereof.
>
> The prize shall not be awarded to any Member of Council or Officer of the Society.
>
> Essays sent in for competition must be received by the Secretary on or before May 31st, in each year.

National Association of Cement Users.—The sixth annual Convention of the National Association of Cement Users of America (Mr. Richard L. Humphrey, M.Am.Soc.C.E., President) will be held on February 21st-25th next at Chicago, U.S.A. The Convention has been arranged to take place during the Chicago Cement Show, which will be held from February 18th-26th. The association have extended invitations to concrete associations in England and abroad, and the Convention will therefore have an international significance, and will be one of the largest gatherings in the world in the history of the cement industry. The Mayor of Chicago will open the Convention, and the following are among the matters which will be discussed: Report of the Committee on "The Exterior Treatment of Concrete Surfaces"; the Use of Concrete for Farm Buildings from the Sanitary Standpoint; Laying Concrete under Water; Concrete for Maritime Structures; Application of Concrete in Barge-canal Work; Comparative Cost and Efficiency of the Pneumatic Reinforced Concrete Dam; Additional Notes on the Use and Cost of Concrete for Small Houses. There will also be a report of the Committee on Building Laws and Insurance, and a report of the Committee on Specifications for Fireproofing.

CHURCH IN ANNAHÜTTE. BUILT IN CEMENT BLOCKS.

TRADE ANNOUNCEMENTS, CATALOGUES, ETC.

The British Uralite Co., Ltd., 16 St. Helen's Place, E.C., have lately placed on the market a solid plaster-asbestos partition. They have been successful in securing a number of contracts for their "Uralite" and "Asbestone" for the walls and roofs of many of the new skating rinks now being constructed all over the country. At their recent Annual Meeting the Chairman announced that the sales of the British Uralite Company's materials had increased by 21 per cent. during the period from July 1st to December 31st, 1909.

The Building and Estates Development Co., Ltd., of Bristol, have sent us an illustrated pamphlet descriptive of their system of concrete construction, and emphasise the fact that under this method it is possible to build monolithic-concrete walls with both vertical and longitudinal cavities or air spaces, and also thoroughly to bond the walls transversely. The patentees claim that a considerable saving in cost may be effected by the use of this sytem, which also obviates the necessity for lining the outside walls, as a thoroughly insulated wall is formed by a combination of air chambers being given according to the width of the wall. A section of a concrete roof is shown constructed on the cavity system, the smooth surface of which makes it available for roller skating. The company are the sole patentees in this country, but we believe that foreign rights may be obtained.

The Cubitt Concrete Construction Co., of Gray's Inn Road, W.C., have issued an interesting pamphlet respecting "Medusa" water-proofing material, for which they are sole London agents. This compound, which has now been on the market for several years, would appear to have a very universal application if one may judge from the list quoted of Government offices, public buildings, and other institutions in which it has been used. Intended for practical use under the ordinary conditions of building construction, it is claimed for "Medusa" that, when added in very small quantity to Portland cement, it makes mortar, or other mixtures of sand and cement, used as a rendering impervious to water, and will greatly extend the field of concrete-construction operations. Special utility is claimed for this preparation in the making of building blocks, cistern and reservoir linings, sewer pipes, conduits, roofing tiles, cellar walls, and in other uses where resistance to the percolation of water is essential.

In addition to photographs of buildings treated with "Medusa" compound, testimonials as to its efficacy, and particulars of some water absorption tests, there are also given some useful instructions as to the mixing in correct proportions and application of the material as a rendering coat.

Expanded Metal in Australia.—Expanded metal has been used in the new Cold Storage Buildings of the Geelong Harbour Trust. It was also used (in conjunction with Kahn bars) for the entire work of floors, girders, and circular staircases of the new Chemical Laboratory for the Australian Commonwealth erected in Melbourne, Victoria. In this work an interesting test was applied by placing 3 ft. of sand over the whole area under test. The span of the main girders was 30 ft. between bearings. The extreme deflection registered was $\frac{3}{16}$-in., but in most cases it registered $\frac{1}{32}$-in to $\frac{1}{8}$-in.

Stuart's Granolithic Co., Ltd., of 4 Fenchurch Street, E.C., inform us that the concrete staircases at Messrs. Arding & Hobbs' premises which withstood the recent fire so well, and which are still in good condition, were supplied by their firm.

Engineering and Machinery Exhibition at Manchester.—This exhibition, which is promoted by *The Engineering Review*, will be held at the City Exhibition Hall, Liverpool Road, Deansgate, Manchester, from October 14th to November 5th, 1910. We understand that special arrangements have been made for the convenience of exhibitors in connection with power, lighting, stand-erecting, etc., the lowest possible figures being charged for all facilities of the kind.

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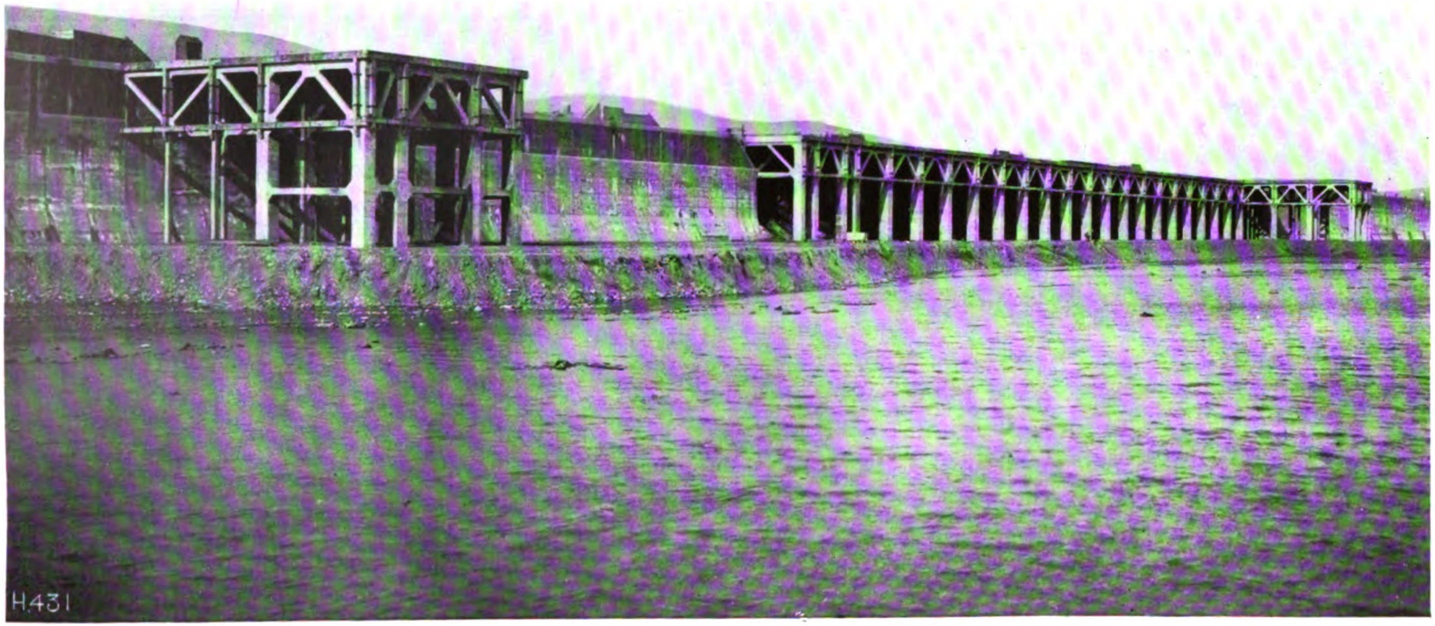


Reinforced Concrete Coaling Quay for Great Western Railway.

REINFORCED CONCRETE QUAYS AT KING'S DOCK, SWANSEA.

Frontispiece.
(Opp. Contents.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 3. LONDON, MARCH, 1910.

EDITORIAL NOTES.

SPECIFICATION FOR PORTLAND CEMENT.

THE news that the Engineering Standards Committee may at an early date issue a further revision of their specification for Portland cement calls attention to the general improvement in the quality of English cement and the better understanding which has undoubtedly arisen between engineers, manufacturers and users since the Committee was instituted in 1904.

All who are interested in the subject are aware that Portland cement is essentially a British invention, though few may realise the fact that its utility has been recognised for at least eighty years since its first production in this country.

Just as in the history of the gentler arts there have been intervals of neglect followed by periods of renascence, so in the history of Portland cement—now recognised as a material of world-wide importance—the stimulus given to improved methods of production by the specifications of engineers, such as the late Mr. Grant in 1860 and Mr. G. F. Deacon in 1875, was followed by a long interval during which but little advance was made.

While the despised foreigner, with the aid of chemistry and the adoption of improvements in grinding machinery, was diligently employed in gaining a position for his product in the markets of the world the British maker of cement, as a general rule, seemed content to rest on his laurels; while the user of cement, although very often himself in fault, made haste to attribute every failure to the manufacturer whose methods were often enshrouded in a veil of impenetrable mystery.

Those who can look back to the history of the trade during the past twenty-five years will recollect that at this conjuncture there appeared upon the scene that useful but often maligned person, the professional cement expert. Meanwhile, the architects and engineers, who were inclined to be sceptical of the doctrine either of the esoteric or exoteric schools of thought represented by the cement maker and the expert, and, moreover, unwilling to occupy the position of the person in the famous triangular duel whose unenviable lot it was to be fired at by both the other combatants at once, held aloof from the controversy, drew their own specifications and had their tests carried out by any of their staff assistants who could be spared for the purpose.

How different is the position to-day, when engineers, architects, experts and manufacturers co-operate to raise the standard of English Portland cement. It is an undoubted fact that the old exclusive attitude of the maker to the user has entirely changed, and a friendly invitation to the latter to visit the works and inspect the *modus operandi* from beginning to end has now become an ordinary incident of the trade.

Meanwhile, the quality of British Portland cement during the last decade has vastly improved, so that it has again become pre-eminent in the world's markets, and its reputation therefore stands higher now than at any period of its history.

CONCRETE INSTITUTE ANNUAL GENERAL MEETING.

WE have received particulars as to the first annual general meeting of the Concrete Institute, which was held at the Royal United Service Institution on February 17th, the Rt. Hon. the Earl of Plymouth, C.B., President of the Institute, in the chair. We have also received a copy of the Annual Report, which we publish under " Memoranda " in this issue.

The Institute are to be congratulated on the excellent progress made during their first year of incorporation. The fact that the membership now numbers over 850 is eloquent testimony to the usefulness and need of such a body.

The work of the Institute has been in the right direction and well merits our praise. The papers presented have been useful ones, and the discussions more than usually interesting. The visits to various works and places of interest have been instructive, but what strikes us as being of most importance is the work done by the standing committees, who even at this early stage have been performing excellent services in the interests of concrete and reinforced concrete both on the scientific and legislative side.

As to the Council for the current year, we are pleased to note that Mr. C. H. Colson, M.Inst.C.E., Mr. J. S. E. De Vesian, M.Inst.C.E., and Mr. William Dunn, F.R.I.B.A., have been re-elected, and the Council are also to be congratulated on the new members added to their number—namely, Professor Henry Adams, M.Inst.C.E., Mr. E. Fiander Etchells, F.Phys.Soc., and Mr. W. G. Kirkaldy, Assoc.M.Inst.C.E., whose services will no doubt prove of great benefit to the Institute.

We are also glad to see by the annual report that the finances of the Institute are in such a satisfactory condition, in spite of the heavy expenses of Incorporation and Parliamentary action, both heavy items in the first year of an institution of this kind.

The annual report throws out suggestions as to future developments, among others that branches of the Institute be formed in provincial towns, and that a Graduate section be formed of juniors who are anxious to study technical matters in concrete and reinforced concrete. It will be interesting to observe how these suggestions are taken up.

LOCAL GOVERNMENT BOARD AND REINFORCED CONCRETE.

We have from time to time referred to the grievances of local authorities and others regarding the shortness of the loan periods granted by the Local Government Board for reinforced concrete structures as compared with the periods allowed on other building materials.

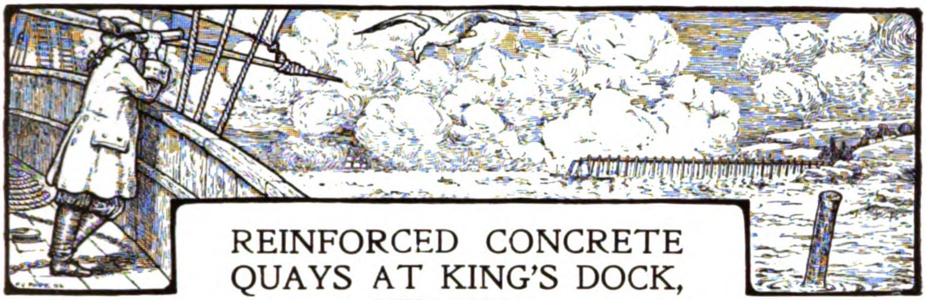
We have strongly advocated that an independent committee on the subject should be formed, representative of the various Government departments who have used reinforced concrete, local authorities and the professional institutions concerned.

The grievance has again been forcibly brought to our notice by an excellent letter on the subject which has been sent us by the Patent Indented Steel Bar Company. Although such a letter obviously might have borne more weight if it had emanated from a professional body, still it states the case very clearly, and we publish it in full and recommend it strongly to the attention of all concerned.

> "The attitude of the Local Government Board or their Engineer in refusing to allow loans to local authorities for the construction of works in reinforced concrete on the same terms as in cases where other materials are used is, by this time, sufficiently notorious. But we think that the hardship inflicted upon small local authorities, and upon firms such as our own, whose business it is to design or carry out work in the material, is not fully appreciated.
>
> "We should like, therefore, to call attention to a recent case (which is far from being an isolated one) in which we have received a letter from our client stating that he has just been informed by the Local Government Board that only ten years can be allowed for a loan with which a reinforced concrete tank was to be constructed, and that, therefore, the project must be abandoned. Several designs for this tank have been prepared by us, and negotiations have been continued between the contractor and our client and ourselves for some months; yet, when these have been brought to a conclusion that is eminently satisfactory to the would-be owners of the tank, owing to the economy both in original cost and upkeep of reinforced concrete as compared with any other material, the whole of the trouble and expense is absolutely thrown away by the action of the Local Government Board. In addition to the waste of labour thus caused, the Local Government Board are preventing the local authorities in question from reaping the benefit of the economy and other advantages of this material.
>
> "That such advantages do exist, and are not merely the product of imagination, is sufficiently proved by the action of the Admiralty, War Office, Board of Works, railway companies and large commercial firms, who have to such a large and increasing extent embarked upon the use of reinforced concrete.

" It is absurd to suppose that such bodies would adopt a material whose life was supposed by their technical advisers to be only ten years. Up to the present, deputations, correspondents, and personal interviews have all met with the same fate and have proved to be utterly ineffectual in obtaining the necessary consideration.

" The President of the Local Government Board is, no doubt, ruled in these matters by his chief technical adviser, but surely when the consensus of professional opinion is so clearly against the advice which appears to be given to him it would be to the public advantage if a committee of independent experts were appointed by the President of the Local Government Board to advise him as to whether the action of his technical adviser is in accordance with the accepted opinion of the engineering profession or is the outcome of a more or less personal bias against the particular material in question."



REINFORCED CONCRETE QUAYS AT KING'S DOCK, SWANSEA.

The new Dock at Swansea, which was opened in November of last year, is one of the most important enterprises ever undertaken by the Bristol Channel Authorities, and will bring Swansea, in the course of the next few years, into the first rank of export ports in the United Kingdom.

In this article we are dealing with the reinforced concrete quays which have been erected on the north side of the coaling arm for a length of 750 ft., and also for the coaling wharves on the south side, 1138 ft. in length.

The particulars contained in this article, as well as the photographs illustrating it, were placed at our disposal by members of the Resident Engineer's Staff.—ED.

AMONGST the many new and important features comprised in Swansea's £2,000,000 dock, which was formally opened in November of last year, there are none which show a greater advance in constructional practice than the two reinforced concrete quays which are designed to carry coal hoists of the latest pattern, both fixed and movable, capable of giving the utmost dispatch to vessels, whether bunkering or loading whole cargoes.

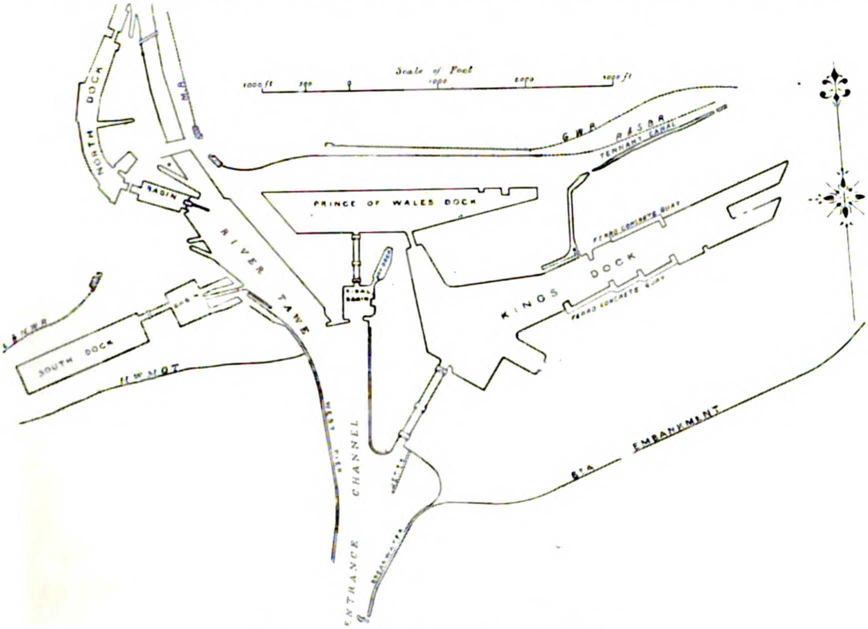


FIG. 1. KEY PLAN OF SWANSEA HARBOUR.

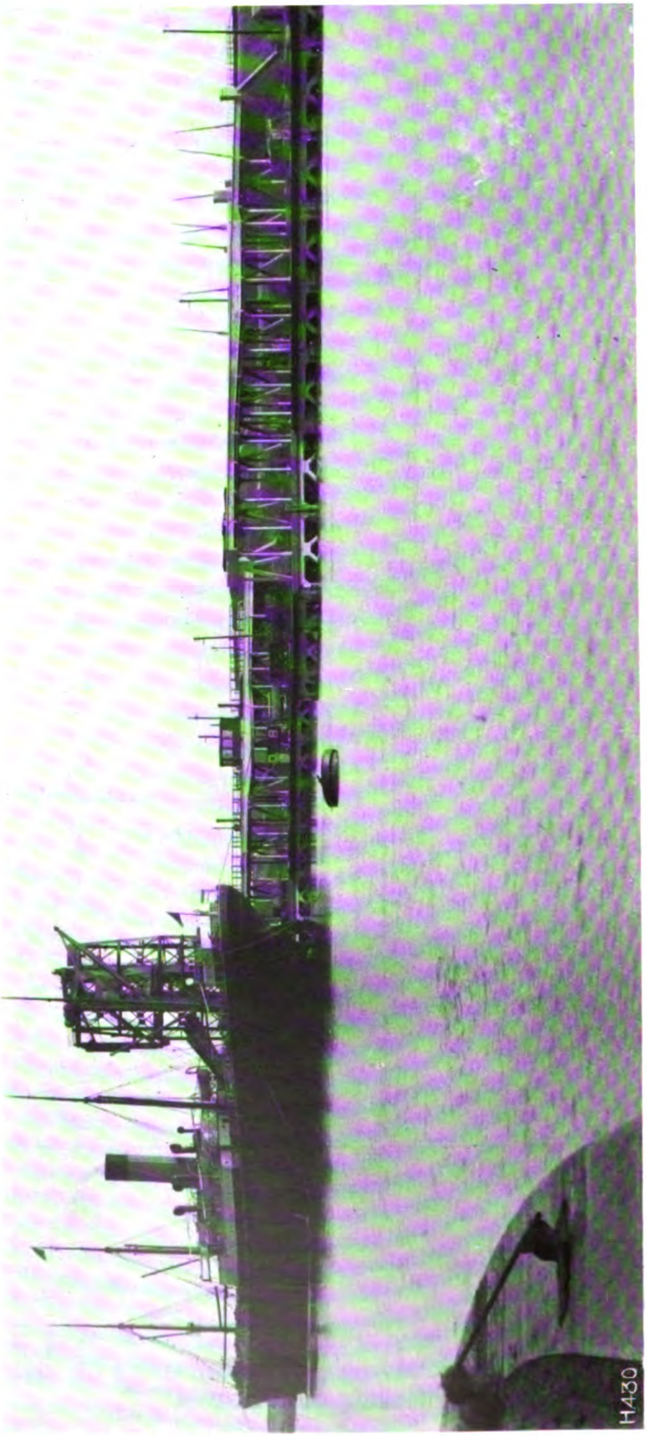


Fig. 2. View of quay and abutments, south side of dock.
Reinforced Concrete Quays at King's Dock, Swansea.

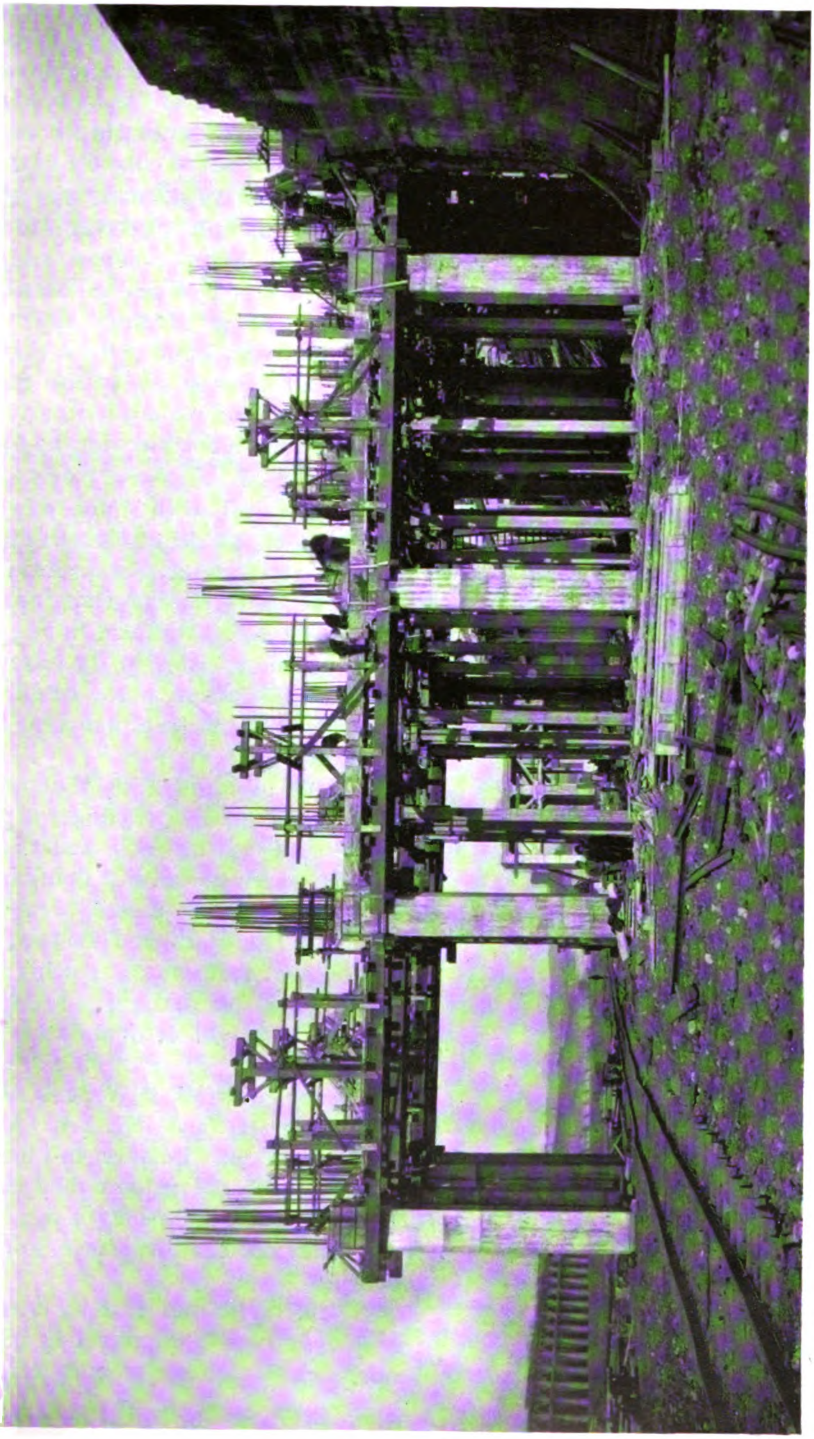


Fig. 3. View of piers for fixed hoists under construction.
Reinforced Concrete Quays at King's Dock, Swansea

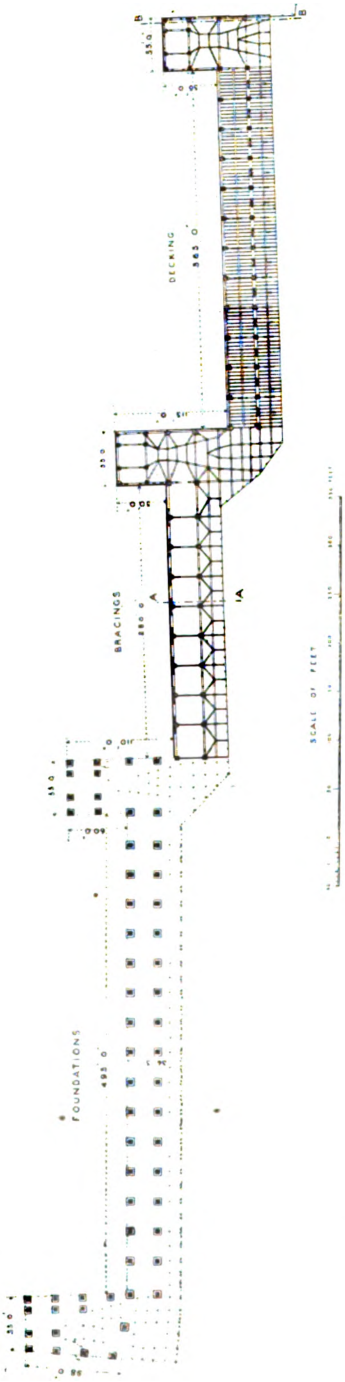


Fig. 4. Plan of foundations, bracings and decking.
Reinforced Concrete Quays at King's Dock, Swansea.

A glance at the key-plan in *Fig.* 1, of Swansea Harbour, will show the enormous addition made to the dock accommodation by the bringing into use of the new King's Dock and the prominent position in the arrangement given to the reinforced concrete coaling quays.

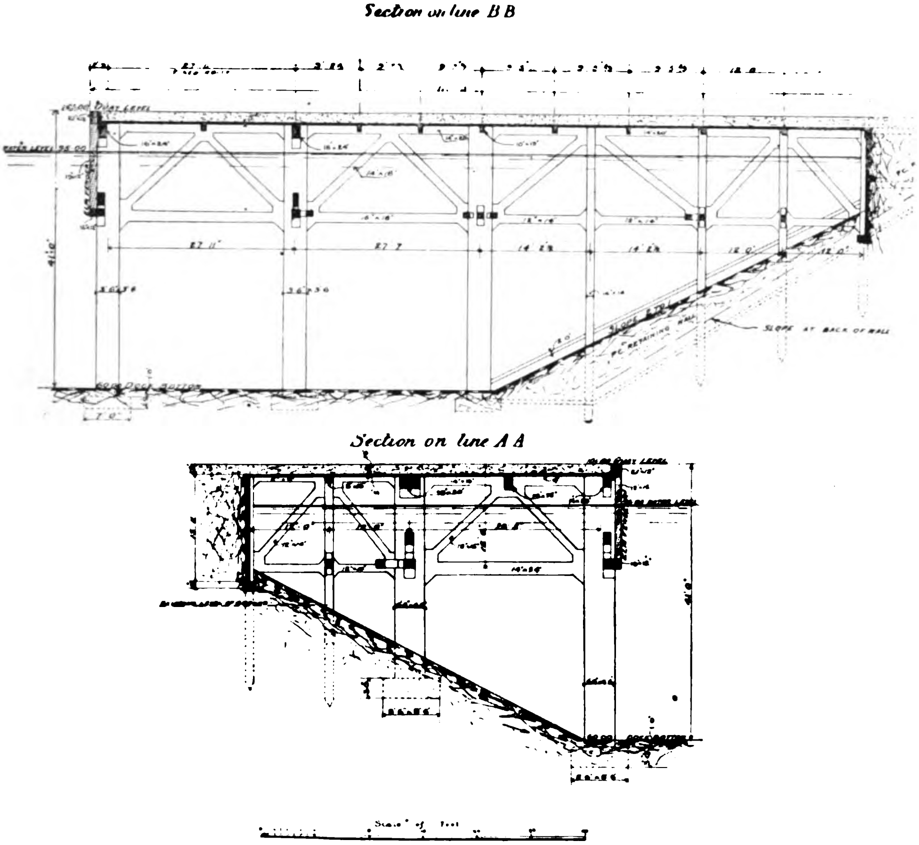
In the original designs it was intended to have fixed hoists only, placed at intervals along the quay wall upon concrete and masonry piers, with pitched slopes in between them, but as the scheme advanced, and the Great Western Railway Company took a frontage of 1,000 ft. on the north side of the dock, it was decided to include a quay for movable hoists between the projecting piers for the fixed hoists.

A design in masonry construction was prepared to deal with these new machines in the form of a series of longitudinal arches extending about 60 ft. back from the quay line, but owing to the uncertain nature of the foundations the cost was held to be prohibitive, and the engineers came to the conclusion that a reinforced concrete quay would be more economical and efficient than any other kind of construction.

In the meantime the Midland Railway Company had taken a frontage of 700 ft. on the south side of the dock, and the Rhondda and Swansea Bay Railway Company already had an option with regard to another strip of quay. The Harbour Trustees, therefore, decided to construct a second reinforced concrete wharf on that side of the dock, and to include a liberal accommodation for their own purposes.

The engineers (Mr. P. W. Meik, M.Inst.C.E., of Westminster, and Mr. A. V. Schenk, M.Inst.C.E., the Engineer-in-Chief to the Swansea Harbour Trustees) then elaborated a quay scheme for both sides of the dock, which is in some ways a departure from previous practice.

It will be noticed that at intervals along the quays there are projecting piers on tip-heads, and that these severally fall behind one another. By this means a vessel, however long, being loaded at one tip, is free to change its position to any extent for convenience in loading into any of its hatches, without in any way interfering with other vessels which may at the same time be loading at the adjoining tips.


Section on line BB

Section on line AA

Fig. 5. Detail Sections.

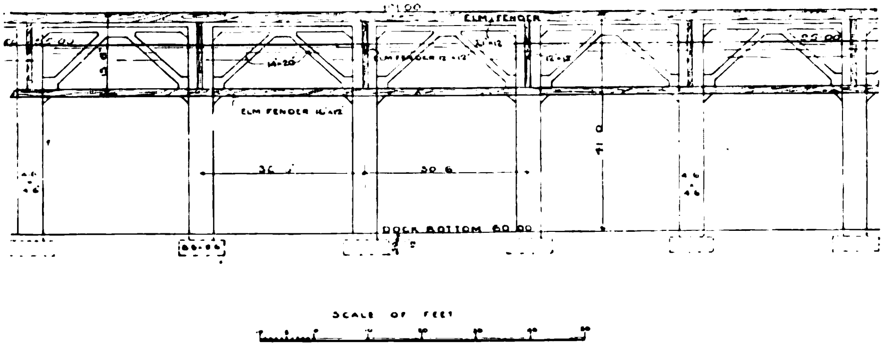


Fig. 6 Front Elevation of Quays.

By this arrangement the great inconvenience which is invariably experienced at " in-line " coaling quays is entirely obviated.

Between the projecting piers are the continuous quays for the movable hoists. Vessels, when moored at these quays, will again be quite clear of those at the projecting quays, and can be served simultaneously by two, or even three, hoists, thus expediting the loading of coal cargoes in an extraordinary degree. Added to the fact that the hoists themselves are designed to work at a speed of 180 ft. per minute, and are served with 8-in. diameter hydraulic mains, it will be seen that the Trustees have dealt with the matter in a liberal and far-seeing manner.

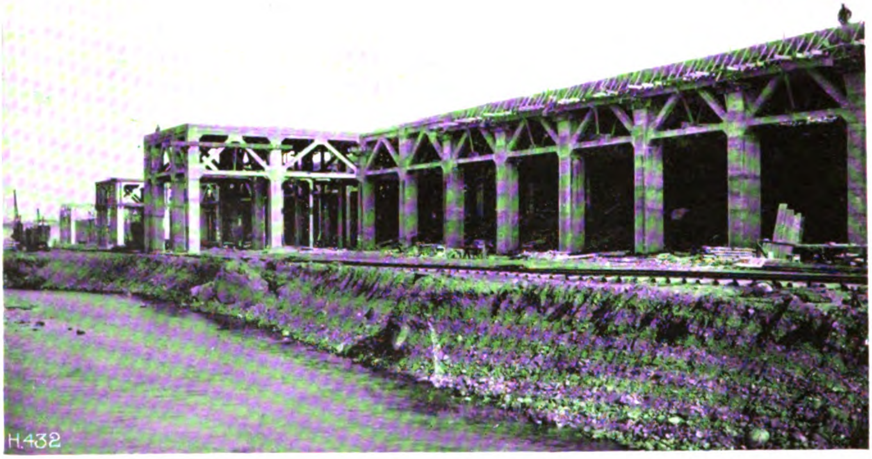


FIG. 7. SOUTH SIDE OF DOCK. REINFORCED CONCRETE QUAY NEARING COMPLETION.

When the south quay is fully equipped it will be possible at one time to load, at the fixed tips, five of the largest class of ships that can enter the lock (the dimensions of which are 875 ft. by 90 ft.), and four other vessels at the quays served by seven movable hoists.

At the Great Western quay there are now being erected three fixed and two movable hoists, which will allow for the loading of three and sometimes four of the largest vessels at one time.

The length of the north-side quay is 1,000 ft., and that on the south side about 1,800 ft.

The depth of water in the dock is usually kept at 35 ft., and the height from the dock bottom to the quay level is 41 ft.

The construction of the two quays being very similar in character, a brief description of that on the south side only will be necessary for the purposes of this article.

The foundations of the structure were mainly in gravel, of varying hardness, whilst in some cases clay pockets were met with, which required certain variations in the design. In one or two places the gravel was so hard that piles could not be driven through it, concrete slabs being substituted in which dummy piles were embedded.

The quays for the movable hoists are divided into bays of about 30-ft. span, and consist transversely of a front and back column square in form, 4 ft. 6 in. by 4 ft. 6 in., with a base slab 8 ft. 6 in. square. These two columns come under the treads of the moving hoists. Behind the back columns two rows of piles are driven, forming the supports for the fixed traverser gantries, along which the traversers carrying the coal trucks will run to feed the movable hoists in their varying positions. The back row of piles also forms an important part of the curtain wall which retains the embankment at the back of the quay.

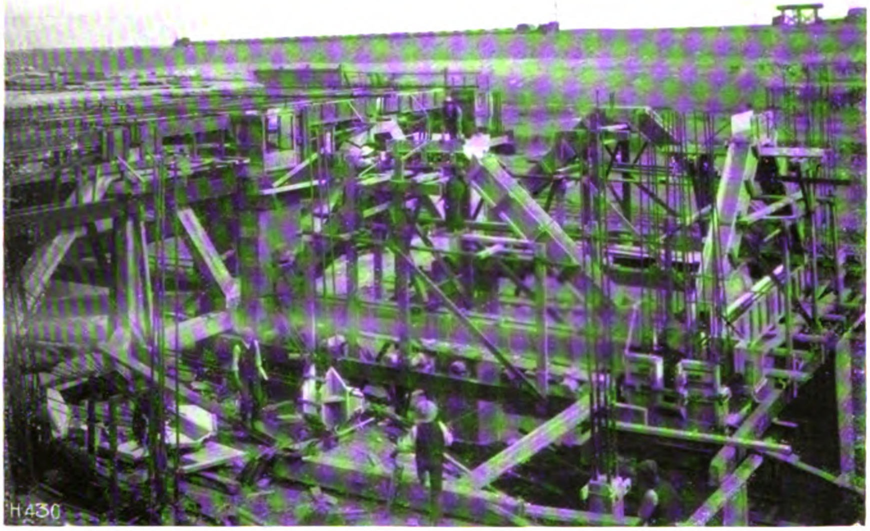


FIG. 8. G. W. Rly. reinforced concrete quay under construction.
REINFORCED CONCRETE QUAYS AT KING'S DOCK, SWANSEA.

At a height of 25 ft. above the dock bottom the columns are strutted and braced both longitudinally and transversely, to give bearing for the beams which carry the decking.

The decking generally is 5 in. thick, and is carried on joists 3 ft. 9 in. apart.

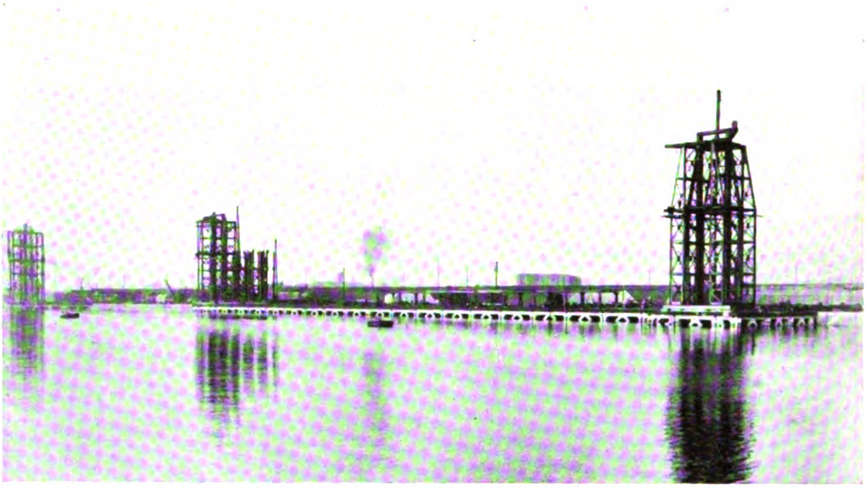
The general dimensions of the structure are detailed on the accompanying plans.

The piers for the fixed hoists are of similar construction to the continuous quays, with the addition of piles for carrying the legs of the overhead gantries which connect the storage sidings with the hoists.

To protect the surface of the decking from the action of the sun and the weather the whole is covered over with a layer of broken stone, topped up with another layer of ashes. The decking is provided with weep-holes, so that the quay is perfectly dry at all times.

The dock face of the structure is protected throughout with elm fenders bolted to the columns and longitudinal bracings.

Reinforced concrete quay for G. W Rly.



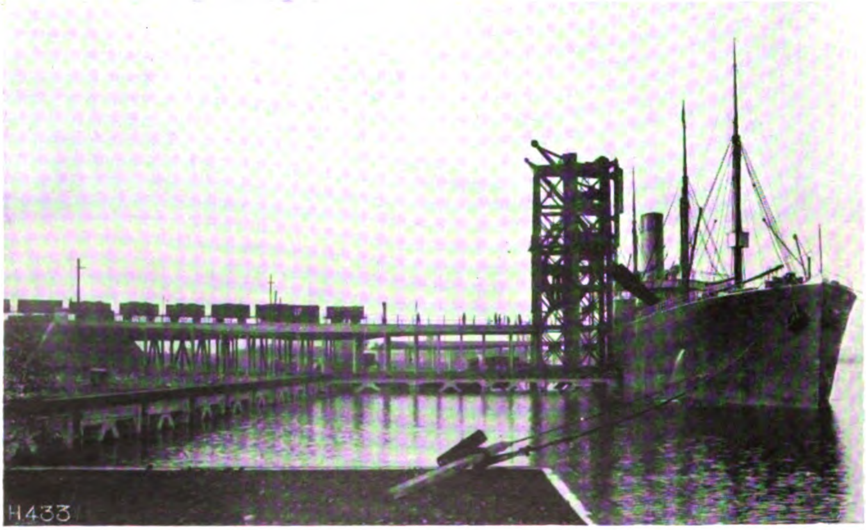


FIG. 9. Reinforced concrete abutments to coil hoists.
REINFORCED CONCRETE QUAYS AT KING'S DOCK, SWANSEA.

The quays have been designed to carry the following loads:

Fixed hoists: 200 tons on front of hoist, 140 tons on back.
Movable hoists: 200 tons on front of hoist, 140 tons on back.
Wheel base of movable hoists: 8 ft. 6 in.—18 ft. 10 in.—8 ft. 6 in.

Traverser gantry: on pillar, 50 tons; on girder, 30 tons at centre.

Decking of wharf: 2 cwts. per sq. ft. between hoist lines; 3 cwts. elsewhere.

In addition to the main quays, three of the approach-line gantries have been constructed in reinforced concrete, with which are incorporated the foundations for turntables, weighbridges, and weighcabins for dealing with the coal coming on to the hoists.

The aggregate from which the concrete was made is as follows:—

27 cu. ft. of clean Guernsey granite chippings (between ½ in. and ¾ in.);
13½ cu. ft. of screened beach sand, from ⅛ in. downwards;
and 7 cwts. of Portland cement.

Such a mixing resulted in 31 cu. ft. of concrete in the work.

Experiments were made by Messrs. Kirkaldy to ascertain the crushing resistance of twelve 6-in. cubes made from the above aggregate, the cement being made in a rotary kiln by the Knight, Bevan & Sturge Branch of the Associated Portland Cement Manufacturers (1900), Ltd.

	Crushed at Tons, per sq. ft. average.
3 blocks broken at the age of 3 months	245·1
3 ,, ,, ,, 6 ,, ...	272·5
3 ,, ,, ,, 9 ,, ...	299·9
3 ,, ,, ,, 12 ,, ...	315·2

An experiment was made during construction to test the strength and soundness of a 14 in. by 14 in. pile, which could not be driven to its specified depth, owing to the hardness of the ground. The pile was driven to the ordinary set with a two-ton monkey falling 6 ft., with the patent Hennebique helmet on the head of the pile. It was then hammered home with an increasing drop, until a drop of 14 ft. was reached. Although the helmet was badly damaged, the head of the pile suffered in no particular, with the exception of a slight sprawling at the arrises.

The details of the construction were designed by Messrs. Mouchel & Partners, of Victoria Street, S.W., and the work was carried out by Messrs. Topham, Jones & Railton, Ltd., of Westminster, who were the contractors for the whole dock scheme. The speed with which they carried out the work testifies eloquently to the perfection of their organisation.

The north quay was commenced in October, 1907, and completed in June, 1908; whilst the south quay was started in April, 1908, and finished in April, 1909.

POSSIBILITIES OF THE USES OF MINERAL OILS MIXED WITH CONCRETE.

By **ALBERT MOYER,** Assoc.Am.Soc.C.E.

The article we are presenting herewith has been sent us by Mr. Albert Moyer, Assoc.Am.Soc.C.E., who is a well-known American authority on all matters relating to concrete. The subject, of the effect of mineral oils on concrete, has been attracting considerable attention in the American Technical Press, and Mr. Logan W. Page is conducting extensive investigations in the Laboratory of the Office of Public Roads at Washington on the matter. A great deal yet remains to be learned concerning this method of preparing concrete with oil, but we hope before long to receive more information on the subject.—ED.

THE mixing of mineral oil with concrete is very simple. The oil, alkalies, and water will form an emulsion becoming thoroughly incorporated in the concrete. If the concrete is to be mixed by hand, proceed as usual, and, after the water has been added and the resulting mass turned and raked, add non-volatile mineral oil in proportion of 10 to 15 per cent. of oil to the weight of the cement. Turn the concrete with shovels two or three times, raking while turning; the oil will quickly emulsify and become thoroughly mixed in the concrete.

If machine mixing is employed, use a batch mixer, turning a sufficient number of times to thoroughly mix the cement, sand, crushed stone or gravel, and water. Then add 10 to 15 per cent. of non-volatile mineral oil. Turn again the same number of times as it requires to mix the concrete; the oil will quickly emulsify and become thoroughly incorporated in the concrete.

Oils added to concrete in proportions of from 5 to 15 per cent. will slightly delay the initial and final set. Increasing the proportions of oil will further retard both the initial and final set and hardening, but up to 15 per cent. From experiments so far made, it would seem that the retarding of hardening will not be sufficient to cause the work to be uneconomical.

The tensile strength will necessarily be reduced, and with the increasing percentages of oil toughness will be slightly diminished, but not in proportion to the increase in the percentage of oil used.

An extremely interesting paper was recently read at the meeting of the Association of American Portland Cement Manufacturers by Mr. Logan Waller Page, Director, Office of Public Roads, Agricultural Department, Washington, on the subject of the possibilities of Portland cement as a road material, in which he described some investigations being carried on by Dr. Allerton S. Cushman in the Laboratory of the Office of Public Roads to ascertain the practicability of mixing semi-asphaltic base oils with Portland cement concrete, with the object of obtaining the desirable properties of both Portland cement and asphaltum. So far, only pats and briquettes have been made; the results so far obtained show ample strength for ordinary work; 6-in. cubes will be tested later.

It is believed that compression tests will show greater strength than the usual relation of compression to tension. This is a matter for further investigation, and it is to be hoped that chemists and cement testers will actively take up this work and carry on investigations covering long time periods.

Tensile strain tests should be discarded. Such tests have now been discarded by the German Portland cement manufacturers and compression tests substituted. With the increased scientific knowledge and the consequent better material produced by Portland cement manufacturers tensile strain tests have become obsolete, and, owing to the brittleness and extreme sensitiveness of neat Portland cement and the unscientific methods employed in tensile strain tests, these tests do not indicate the possible load which Portland cement-concrete may carry.

The author, therefore, would earnestly advocate compression tests on cylinders of a size which will cause the area to equal 6-in. cubes. In order that such tests may be standardised and relative, standard sand should be used, and, if possible, a standardisation of gravel or crushed stone. If crushed stone, trap rock should be used, all passing through a ¾-in. mesh and all collected on a ¼-in. mesh. Mix up cylinders, which will theoretically figure maximum density, add varying proportions of oil from 5 to 20 per cent. Also make up another set of cylinders, adding varying proportions of hydrated lime from 10 to 30 per cent., increasing the percentage of oil with the increase of hydrated lime. The addition of hydrated lime theoretically should permit the addition of a larger percentage of oil, as we thus have a greater emulsifying material. Varying percentages of Portland cement may be used, always keeping the relation between the sand and stone the same, maximum density having been figured. The amount of Portland cement to be increased above that which is required to fill the voids in the sand.

A few months ago the writer made some briquettes and pats with the object of ascertaining if the mixture of oil with wet neat cement and mortar would have the tendency of keeping all but the excess water from leaving the wet neat cement or mortar.

Briquettes were made, neat cement mixed with water, the water slightly in excess of that usually required, after which 10 per cent. of oil petrole was added. (Oil petrole is a white non-volatile petroleum product of about the consistency of melted vaseline.) Pats were made of 1 part cement, 3 parts sand mixed with water, a little in excess of what would ordinarily be used, after which 10 per cent. of the same oil was added. These pats are about 2½ in. in diameter and ¼ in. thick.

As soon as made they were left in dry air, the initial and final set was found to be normal. They were never immersed in water, but remained in dry air for several weeks. No cracks occurred, and they became so hard and strong that these pats—¼ in. thick—were very difficult to break by using the fingers and thumbs. After remaining in dry air for three weeks they were put out in freezing temperature for three days, and again placed in dry air over the radiator. No cracks or checks have occurred.

After remaining in dry air for a month a test for absorption was made. A broken pat was weighed dry and found to weigh $\frac{83}{84}$ oz. It was then immersed in water for several hours. Upon removal from the water the surface was quickly removed with blotting paper, the pat immediately weighed and found to weigh $\frac{88}{84}$ oz. Only $\frac{5}{84}$ oz. of water was absorbed.

The fact that the pats were never immersed in water and showed no evidence of checking or cracking, and became hard, would indicate that the emulsified oil had held the water in the mortar and that such mortar was, therefore, both non-evaporative and non-absorbent, which would tend to show that concrete in which mineral oil has been mixed would not be likely to contract and therefore contraction cracks avoided.

Under the theory of Prof. Bauschinger, which has been demonstrated by Prof.

Swain in the Laboratory of the Institute of Technology, Boston, neat cement when set and hardened in air contracts, and this contraction increases with age up to a certain period, possibly six months or a year. 1 part Portland cement, 3 parts sand hardened in air shows contraction, but less in proportion than neat cement. The results also prove that neat cement when hardened under water shows a slight expansion, while mortar composed of 1 part Portland cement and 3 parts sand, hardened under water, shows expansion, but less in proportion than the neat cement. Reducing these conclusions to figures and taking the average results obtained by various authorities, figuring the expansion and contraction by percentage the following are the results :—

Neat Portland cement hardened in air at the end of 16 weeks shows ·15 per cent. contraction.

1 to 3 mortar hardened under water at the end of 16 weeks shows ·05 per cent. contraction.

Neat Portland cement hardened under water at the end of 16 weeks shows ·05 per cent. expansion.

1 to 3 mortar hardened under water at the end of 16 weeks shows a ·015 per cent. expansion.

Mixing oil with concrete from the meagre tests so far made would seem to indicate that the oil held the water in the mortar, keeping the cement particles wet, and thus furnishing the same conditions as if set under water, hence very materially preventing, if not altogether obviating, contraction cracks and hair cracks. Furthermore, the resulting mortar appears to be far less brittle, and therefore such treatment should admirably serve the purposes required for concrete retaining walls, foundations, enclosing cellars, tanks, cisterns, etc.

Exhaustive tests have been made by a number of authorities on the action of oils on concrete. The effects of oil on concrete and the effect of oil emulsified in concrete are two separate and distinct subjects.

We are informed by reliable authorities that concrete immersed in animal or vegetable oils will in time disintegrate and that concrete immersed in mineral oils is unaffected. In the first instance there was no chance for the oil to emulsify; in the latter the oil is separated into minute globules. A large field of usefulness is ready for oil mixed and emulsified in concrete. The emulsion takes place after the oil is mixed with the wet concrete and not before, as has been done in a patented article.

A mere casual glance at the uses of Portland cement concrete would indicate that oils mixed with the concrete would prove very desirable for dustless waterproof floors for office buildings, for slaughter-house non-absorbent floors, impervious concrete drain tile and sewers. If the experiments to be carried on in the future prove that mineral oils in the course of time are not disadvantageous, the drain tile problem has been solved, for there can be no action of the alkalies or other injurious elements to non-absorbent, dense and impervious concrete.

Such concrete will be particularly desirable for silos. Some of the acids formed by the silage in the bottom of the silo would probably not attack a dense, non-absorbent, impervious concrete.

Contraction cracks will be eliminated in cisterns, drinking troughs, live stock feeding floors and platforms. Some objection may be raised to the use of oil-mixed concrete from the standpoint of its liability to flavour the water or the food. If we stop to consider that the oil is divided into minute globules, thoroughly emulsified, we will see that, while there may be some odour, there is not likely to be any taste after the drinking trough, feeding floor or cistern has been in use for a few days.

Such oil-mixed concrete will be effective for liquid manure cisterns for the reason above described. It will also be particularly adapted to terrazzo floors; the great objection at present being due to contraction cracks. A white oil may be mixed with Portland cement, white sand and water and used for the purpose of setting brick and stone; it being non-evaporative and non-absorbent no efflorescence or stains can occur. In fact such concrete can be used in any work not requiring extraordinary compression strength, and in which the concrete does not come in contact with heat.

One of the particular advantages will be for stucco work and exterior plasters.

It would seem that this idea of mixing oil with wet mortar was novel and new, but, like many discoveries, it only proves to be a rediscovery. In the first century A.D., Marcus Vitruvius Pollio, the famous Roman architect, gives the following detailed specification for stucco: "A mixture of well hydrated lime, marble dust and white sand mixed with water, to which mixture is added either hog's lard, curdled milk or blood." In A.D. 1280 at Rockingham Castle, England, melted wax was mixed with the mortar. In A.D. 1324 in the work of King Edward II. at Westminster pitch was mixed with mortar.

The permanency of the Roman stuccoes may be partially accounted for by the use of oil mixed with mortar. Although Vitruvius used hog's lard, an animal oil, the mortars have withstood the action of the centuries, and in places where freezing temperature occurs in winter and great heat in summer. However, the hog's lard must have been very thoroughly emulsified by the action of the hydrated lime. Portland cement was unknown at that time.

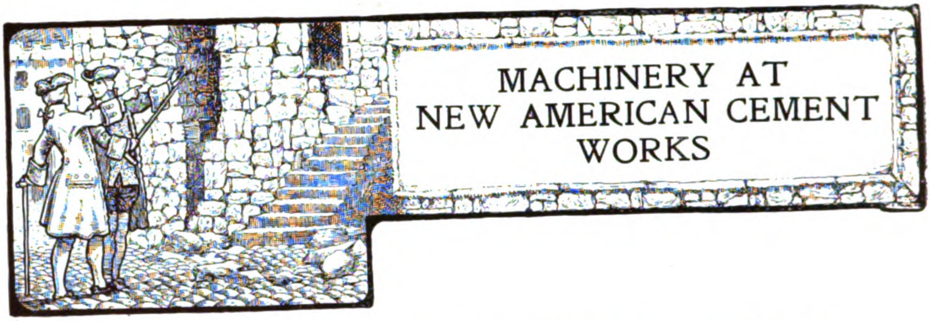
In this connection the author would like to suggest the following specification for stucco, the third or finish coat:—

One part Portland cement, 20 per cent. (volume of cement) of hydrated lime, 3 parts coarse white sand. First dry mix the sand and cement, and with this mix dry hydrated lime, turning each three times with shovels, rake while shovelling. Add water, turning and raking until the desired consistency is obtained. Then add 15 to 20 per cent. of white oil petrole, the oil to be by weight in percentage to the weight of the cement. A gallon of oil petrole weighs 7½ lb. Apply this mortar while the scratch coat is damp and as soon as scratch coat is firm enough to stand the pressure or plastering. If it be desirable to tint the stucco, colour the oil with any limeproof colouring matter, in proportion which by experiment with small samples is necessary to give the desired tint.

A white non-volatile mineral oil is suggested for stucco and for mortar to be used in setting white marble or light coloured brick, on account of the colour possibilities. For concrete where the colour is not essential the heavy black bituminous oils to the light non-volatile petroleum oils are successful. They are cheap and their name is legion.

Do not use oils containing organic matter, and positively avoid, at least for the present and until further experiments have been made, vegetable or animal oils, as they are liable to form an acid which in turn may disintegrate the concrete.

Lime, sand and animal oils have stood the test of centuries. Portland cement and animal oils have not yet had this opportunity. It is within the range of possibility that the test of time may prove contrary to the theory, and animal oils emulsified be found not dangerous; we will then consider a remark made by a very noted chemist: "If theory conflicts with the fact, we will have to change the fact."



MACHINERY AT NEW AMERICAN CEMENT WORKS

The account which we are publishing in this article of the new plant for the Altoona Portland Cement Co. should prove of interest to our readers, giving, as it does, particulars of the various machinery employed in the operation of these works, particular attention being devoted to the Maxecon-Kent mills used for the purpose of raw grinding.—ED.

OWING to the great necessity for reducing manufacturing expenses in the cement industry, under the present market conditions, the following description of one of the latest American works may prove of interest to our readers, although it must be borne in mind that some of the new arrangements would not be applicable in this country.

This new plant, which was started in operation early in May, 1909, belongs to the Altoona Portland Cement Co., and is located about five miles north of Altoona, in Kansas, and comprises 440 acres, containing raw material, and 8,000 acres of gas leases. The mill proper is designed for five 8 × 125-ft. kilns, with a rated capacity of 3,000 barrels of cement per day. The foundations and walls of all the buildings are of

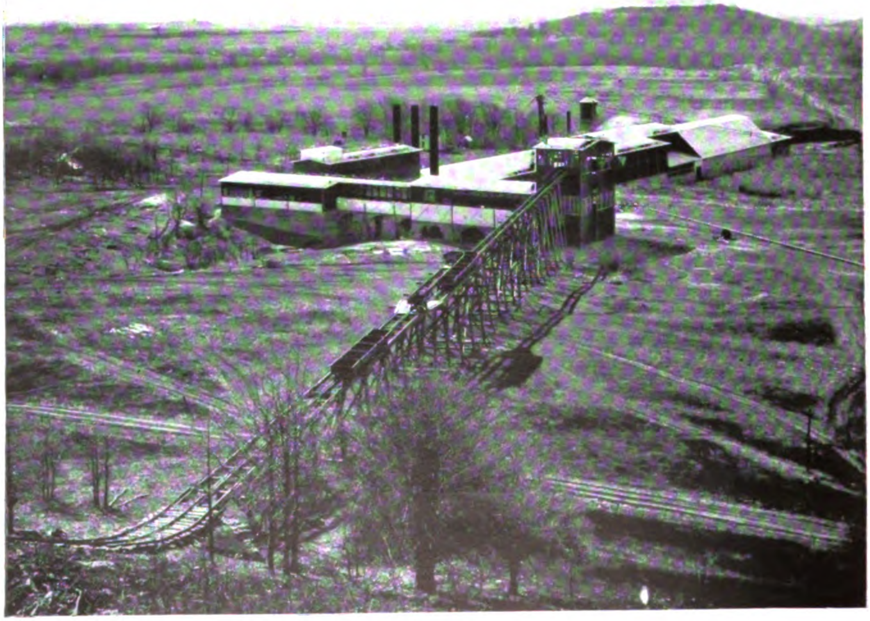


FIG. 1. VIEW OF WORKS FROM QUARRY.

concrete, the columns and roof trusses of steel, and the roofs of the individual buildings are covered with asbestos roofing.

The quarry is located a short distance north of the plant about 170 ft. above the railroad, and contains 190 acres of limestone and about 100 acres of gumbo soil from the flood plain of the Verdigris Valley. The natural elevation of the quarry permits the use of the gravity system, which makes it possible to bring the rock to the mill at a low figure. Electric air drills are employed, and the rock is brought by automatically dumping cars to a large giratory crusher, driven by a 50 h.p. electric motor, the empty cars being returned to the quarry by the weight of the loaded cars.

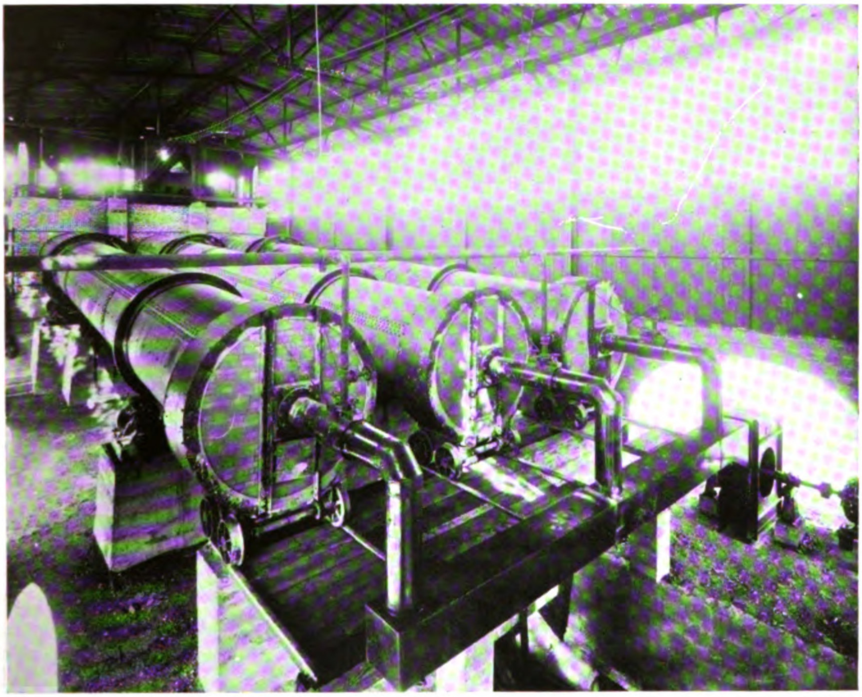


FIG. 2. DISCHARGE END OF DRYER, SHOWING BURNERS AND BLOWERS.

The gumbo is procured by an overhead cableway and a steel dump scoop operated from the hoisting tower, and is thus automatically dumped and fed to a clay pulveriser operated by a 35 h.p. motor, while the power equipment for handling the gumbo consists of a 50 h.p. three-phase motor driving a three-drum hoist.

The rock when crushed to 2½-in. ring is further reduced by two hammer mills (each driven by a 50 h.p. motor) and fed to two rotary driers, while the gumbo from the clay pulverizer passes another rotary drier, both operations being obtained by gravity. The driers are 6 x 60 ft., and individually operated by 15 h.p. variable speed motors. The driers discharge the rock and clay respectively on to two 18-in. belt conveyors, transferring the dried material into the raw storage bins, which are constructed of reinforced concrete, with a capacity to supply the mill for four days. From these bins the raw material is brought into steel storage bins feeding automatic weighing and mixing apparatus, and from these to the bins above the raw material grinding mills.

Eight Maxecon-Kent mills in connection with air separators are employed for the purpose of raw grinding, each mill being driven individually by a geared 32 h.p. constant speed induction motor.

This mill, which is shown in *Figs.* 4-7, is based on the well-known Kent grinding system, having a free movable grinding-ring and three rolls supported against the interior surface of the grinding ring, with an adjustable pressure of approximately 10 tons, the grinding work being done solely between the ring and each roll.

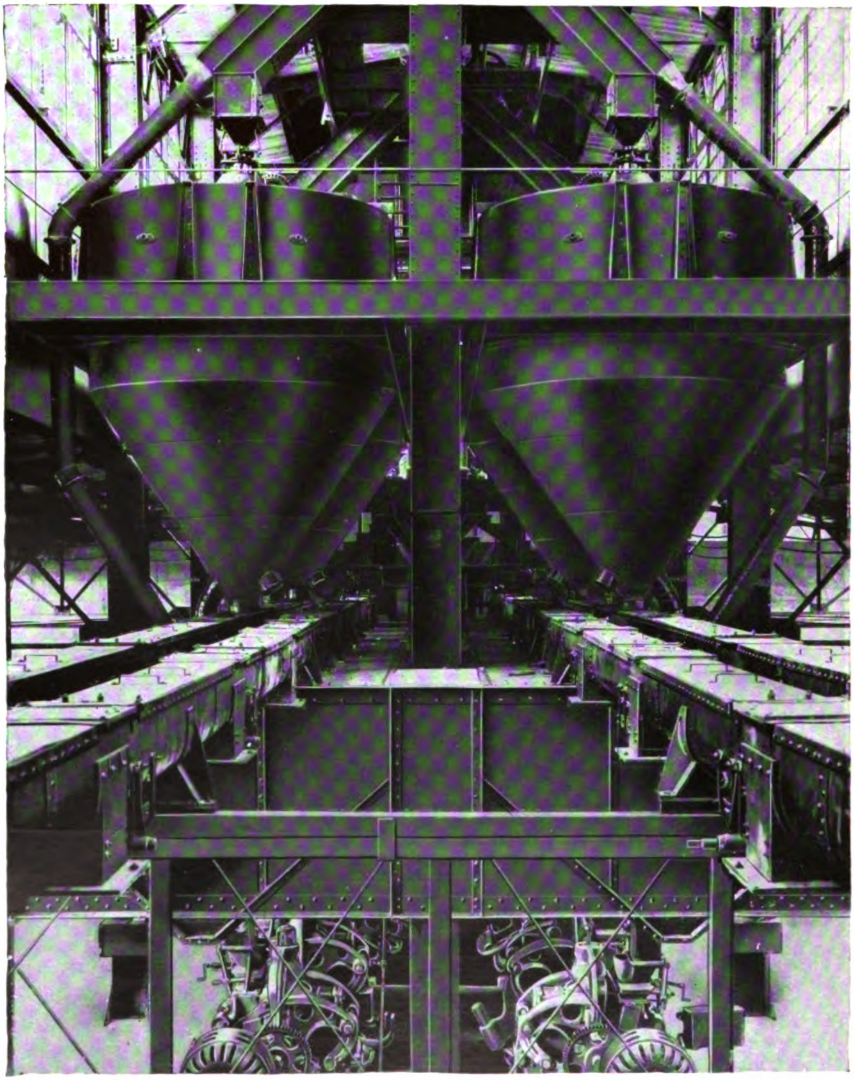


FIG. 3. RAW MILL, SHOWING KENT MILLS AND BINS.

The yielding support of all four grinding parts increases the crushing capacity and reduces the bad effect of shocks and vibrations, so that these mills can be erected on any strong timber foundation, and practically run without the noise generally incidental to crushing and grinding work. *Fig.* 6 shows the accessibility to the grinding parts. Whether the gear drive by electric motor is an advantage might seem doubtful, yet it is interesting that in this entire works only a single belt-driven machine is erected—viz., the above-mentioned giratory crusher. Kent and Maxecon mills, belt-driven by electric motors, have been, however, frequently used in America as well as here, and there is no doubt that, wherever electricity can be had or produced at a reasonable figure per unit, it is the ideal power to drive this kind of plant, because it makes each individual grinding aggregate entirely independent of the other.

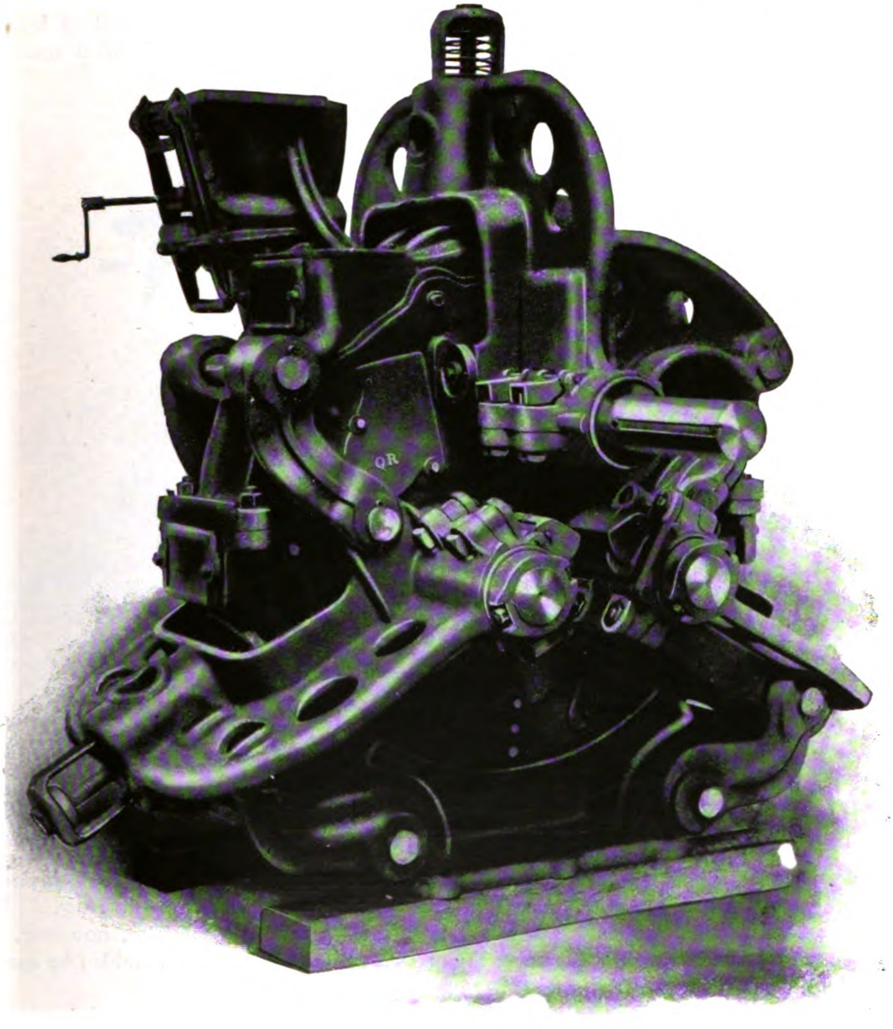


FIG. 4. SIDE VIEW OF MAXECON MILL.

The method of mixed fine and rough grinding and air separation is used in this plant, which insures a thorough mixture and uniformity of product. The fine product coming from the separators is brought by screw conveyors to steel supply bins over the kilns, while the coarse tailings go by gravity back into the mills. These fine bins have a capacity of ten hours' supply to the kilns.

Separated from the raw grinding department is the kiln room containing three 8 x 125 ft. rotary kilns, with ample space on each side for the erection of two additional kilns. Each kiln is driven individually by a 25 h.p. variable speed motor, geared to the driving gears of the kilns.

The fuel is natural gas. The kilns discharge into a pit from which the hot clinker is transported by an electric travelling crane carrying a clamshell bucket, distributing the clinker in the storage room. This electric crane is also used for transporting the seasoned and cooled clinker to the supply bin erected over a hammer mill, which only crushes the large pieces of clinker to about ½-in. ring. The Maxecon mills, which are also used for the clinker grinding, will take, however, the clinker up to 1-in. ring. At this point the proper amount of gypsum is added by means of an automatically operating weighing and dumping device.

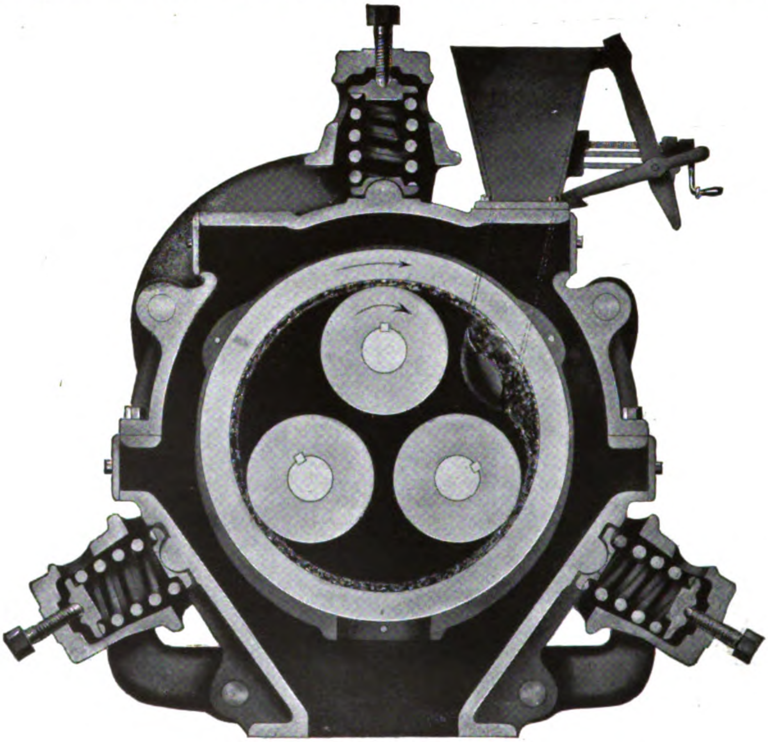


FIG. 5. SECTION OF MAXECON MILL.

The clinker-grinding department is an exact duplicate of the raw material grinding plant, also containing eight Maxecon-Kent mills operating in conjunction with air separators, each mill being driven individually by a 32 h.p. geared motor.

From the finishing mill the cement is conveyed to elevators which feed into 18-in. belt conveyors, from which the finished cement is distributed into three separate storage bins having a total capacity of 120,000 barrels. These storage bins are also constructed of reinforced concrete, steel trusses and columns support the roof, which is covered with asbestos roofing laid on 1¾-in. yellow pine tongue and groove sheeting. From the stock bins the finished cement is conveyed by 14-in. screw conveyors to the sacking room, feeding the bins of the automatic packers. The shipping room covers an area 60 x 75 ft., offering ample room for convenient working and also storage for sacked cement.

Attention is called to a few original features of this mill, the most noteworthy of which is that the raw material storage bins, raw grinding mill, kiln room, clinker storage, finishing mill, stock house and sacking room are all in one building entirely connected, of concrete steel and under one roof, making this main building 820 ft. long and 75 ft. wide. The steel bins in the raw and finishing mills are directly supported by the columns supporting the roof trusses. By following this design considerable saving was effected in building material and cost of erection.

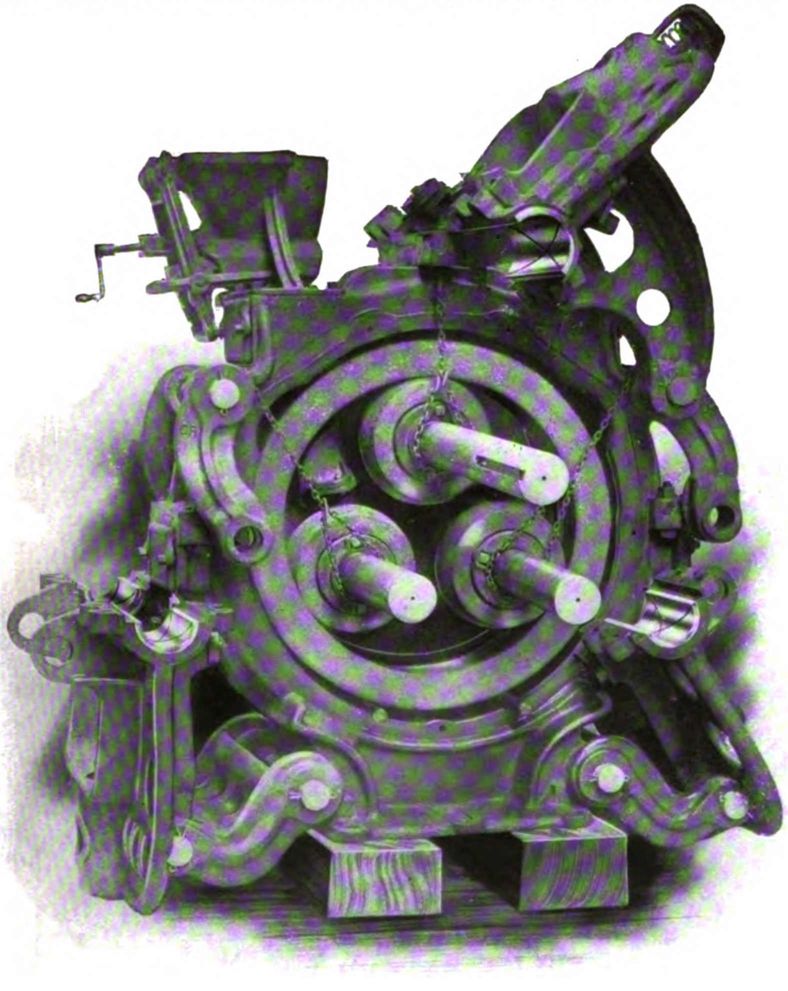


FIG. 6. MAXECON MILL OPEN FOR EXCHANGING GRINDING PARTS.

All the machinery is driven individually by motors connected direct or geared in order to obtain the necessary speed; this means that belt drives, pulleys and line shafting do not exist, whereby a considerable saving in repairs and cost of maintenance is claimed to be obtained. The mill is, according to the *Cement Record*, one of the most

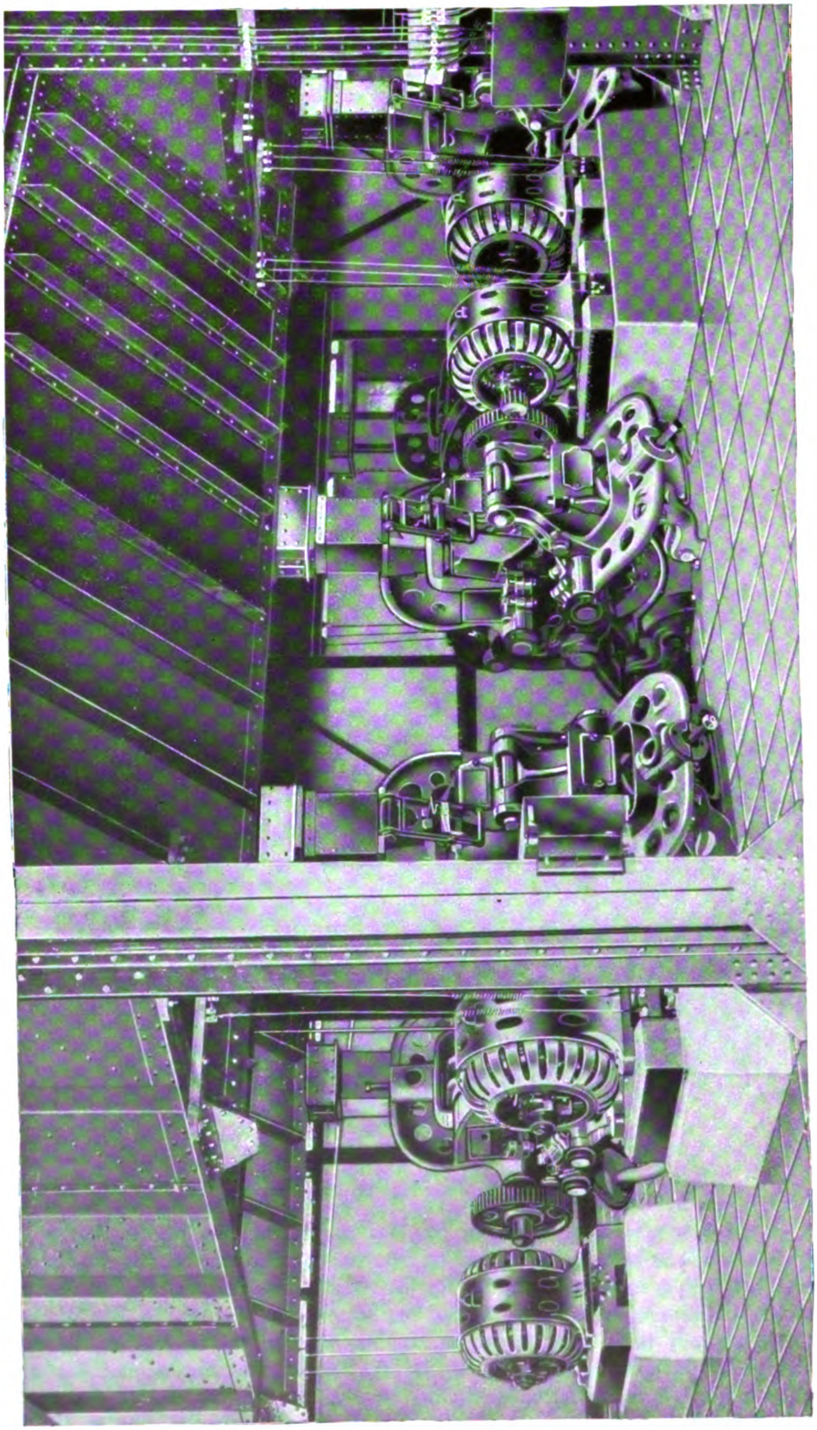


Fig. 7. Finishing Mill. Kent Mills Driven Individually by Geared 32 H.P. Motors.

modern and best equipped cement mills in America, and owing to the results already obtained, another large cement works on very similar lines is in course of construction,

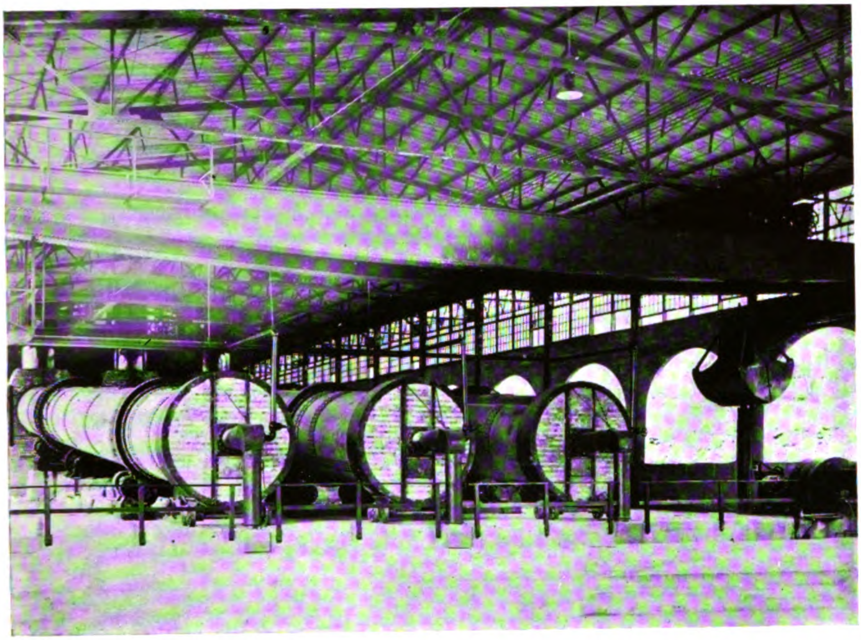


FIG. 8. KILNS. CRANE FOR TRANSPORTING CLINKER AND CLINKER STORAGE IN FOREGROUND.

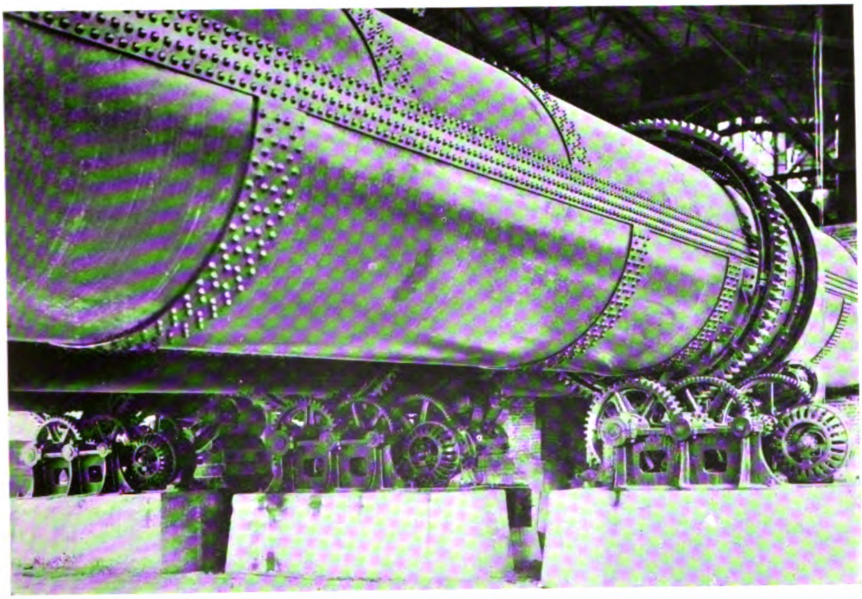
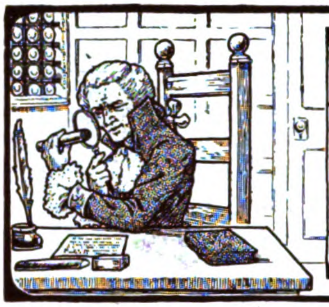


FIG. 9. KILN DRIVES, MOTOR GEARED TO KILN GEAR BASE.

which will be, however, of a much larger capacity, with 32 Maxecon-Kent mills for raw material and clinker.



TESTS ON REINFORCED CONCRETE CONDUCTED IN GREAT BRITAIN.

(PART VI.)

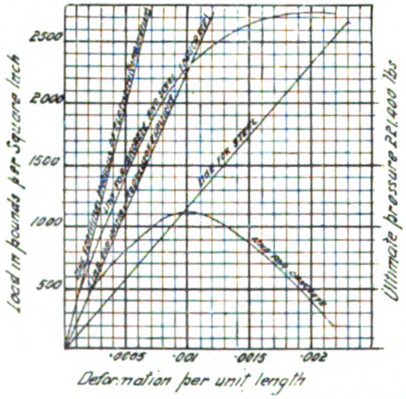
The first five articles of this series appeared in our May, September, November, January and February numbers respectively. The following particulars of tests are now presented, and further articles will appear from time to time.—ED.

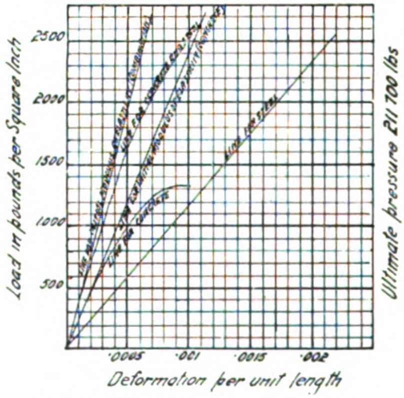
TESTS FOR H.M. OFFICE OF WORKS.

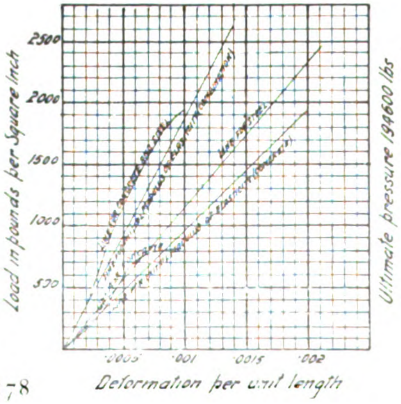
A NUMBER of tests were conducted upon plain and reinforced concrete columns and beams for H.M. Office of Works, under the direction of Sir Henry Tanner, in connection with the extension of the General Post Office, constructed on the Hennebique system. It will be seen that the tests range over a considerable period.

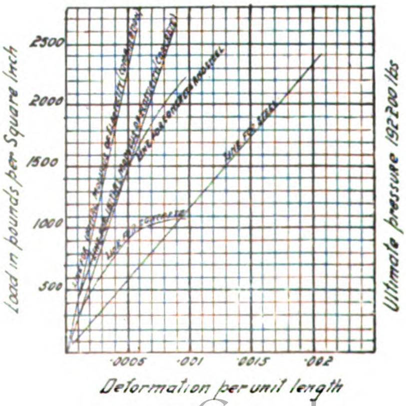
We also record in the same connection some tests on plain concrete cubes so as to provide some idea of the resistance of the concrete. The steel was ordinary mild steel, passing the ordinary specification of 28 to 32 tons tensile strength per sq. in. These tests were conducted by Messrs. David Kirkaldy & Son, and we give in the following tables full details obtained from reports made by Messrs. Kirkaldy, and details of the composition as supplied by the Clerk of Works of the General Post Office Extension Works.

We also give below diagrams prepared by Mr. T. Aubrey Watson, A.M.Inst.C.E., who had charge of the work for Messrs. Holloway Bros., Ltd., the contractors, referring to four of these tests on columns, and based on the allocation of the distribution of stresses by the elastic theory.









RESULTS OF EXPERIMENTS BY MESSRS. D. KIRKALDY & SON TO ASCERTAIN THE RESISTANCE TO DEPRESSION UNDER A GRADUALLY INCREASED THRUSTING STRESS OF SIX REINFORCED CONCRETE COLUMNS, RECEIVED PER MR. F. WOODWARD, CLERK OF WORKS, GENERAL POST OFFICE EXTENSION.

Test No.	Description	Length	Base Area	Stress in Pounds, Depression, inch, at										Ultimate Stress			Remarks
				40,000	60,000	80,000	100,000	120,000	140,000	160,000	180,000	200,000	220,000	Total	Per sq. in.	Per sq. ft.	
		in.	sq. in.											lb. tons	lb.	tons	
QQ	Made July 8th. Concrete mixed fairly dry in following proportions: 1 yd. screened Thames ballast (crushed to pass ¾" mesh), ½ yd. Thames sand, 6 cwt. Portland cement; machine mixed. 4-1" dia. steel bars spaced 5" centres, stayed with $\frac{3}{16}$" wire links at intervals (as shown in sketches)																
4637*	See *Fig.* 1, below ..	72·70	81·00	·010	·017	·024	·031	·038	·046	·056	·068	·087	·158	221,400 98·8	2,730	175·6 } 171·0	Visibly cracking at 218,600 lb.
4638*	See *Fig.* 2, below ..	72·70	81·81	·010	·015	·021	·027	·033	·040	·048	·057	·069	—	211,700 94·5	2,588	166·4	Visibly cracking at 211,700 lb.
4639*	See *Fig.* 3, below ..	73·30	82·17	·009	·016	·024	·031	·038	·046	·056	·067	·092	—	203,600 90·9	2,478	159·4 } 155·0	Visibly cracking at 198,700 lb.
4640†	See *Fig.* 4, below ..	73·08	81·45	·010	·016	·022	·029	·036	·043	·052	·066	—	—	190,800 85·2	2,343	150·7	Visibly cracking at 190,800 lb.
4641†	See *Fig.* 5, below ..	72·72	81·18	·010	·017	·024	·031	·038	·045	·057	·074	—	—	194,600 86·9	2,397	154·1	Visibly cracking at 194,600 lb.
4642†	See *Fig.* 6, below ..	73·11	80·55	·007	·014	·020	·028	·036	·044	·056	·069	—	—	192,200 85·8	2,386	153·4	Visibly cracking at 192,200 lb.

Particulars of composition and reinforcement, etc., are taken from Mr. F. Woodward's letter of October 9th. Initial stress, 20,000 lb. Ends of columns were prepared true for testing. All the columns failed by crushing at about 1 ft. from the top end.

* Tested October 31st, 1908. † Tested November 2nd, 1908.

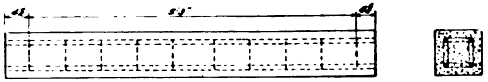


Fig. 1. $\frac{3}{16}$" Binding Ties spaced 7" apart. 9·01" × 9·00" Marked A

Fig. 2. Do. 9·07" × 9·02" Marked A

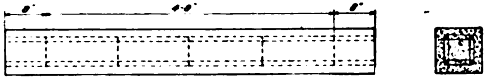


Fig. 3. $\frac{3}{16}$" Binding Ties spaced 14" apart. 9·10" × 9·03" Marked B

Fig. 4. Do. 9·07" × 8·98" Marked B

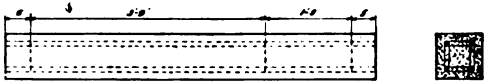


Fig. 5. $\frac{3}{16}$" Binding Ties placed at random. 9·02" × 9·00" Marked C

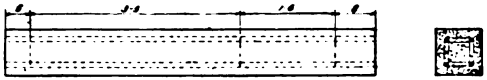


Fig. 6. $\frac{3}{16}$" Binding Ties placed at random. 9·01" × 8·94" Marked C

H.M. Office of Works. **NEW GENERAL POST OFFICE.** *Report No. 16.*

RESULTS OF EXPERIMENTS BY D. KIRKALDY & SON TO ASCERTAIN THE RESISTANCE TO DEPRESSION UNDER A GRADUALLY INCREASED THRUSTING STRESS OF SIX REINFORCED CONCRETE COLUMNS, RECEIVED PER MR. F. WOODWARD, CLERK OF WORKS, GENERAL POST OFFICE EXTENSION.

Test No.	Description	Length	Base Area	Stress in Pounds, Depression, inch, at										Ultimate Stress				Remarks
				40,000	60,000	80,000	100,000	120,000	140,000	160,000	180,000	200,000	220,000	Total	Per sq. in.	Per sq. ft.		
		in.	sq. in.											lb. tons	lb.	tons		
RR	Made Jan. 14th. Concrete mixed fairly dry in following proportions: 1 yd. screened Thames ballast (crushed to pass ¾" mesh), ¼ yd. Thames sand, 6 cwt. Portland cement; machine mixed. 4-1" dia. steel bars spaced 5" centres, stayed with ³⁄₁₆" wire links at intervals (as shown in sketches)																	
1010	See *Fig.* 1, on next page	72·58	81·09	·009	·017	·025	·032	·039	·046	·058	·075	·116	·143	224,800 100·4	2,772	178·3	184·2	Visibly cracking at 198,300 lb. (88·5 tons).
1011	See *Fig.* 2, on next page	72·56	81·45	·008	·015	·021	·028	·036	·044	·052	·065	·080	·112	240,800 107·5	2,956	190·1		Visibly cracking at 235,700 lb. (105·2 tons).
1012	See *Fig.* 3, on next page	72·66	80·64	·010	·017	·024	·030	·037	·045	·055	·070	·096	—	216,600 96·7	2,686	172·7	169·7	Visibly cracking at 200,000 lb. (89·3 tons).
1013	See *Fig.* 4, on next page	72·60	81·81	·008	·015	·022	·029	·037	·045	·056	·078	·106	—	212,200 94·7	2,594	166·8		Visibly cracking at 196,400 lb. (87·7 tons).
1014	See *Fig.* 5, on next page	72·78	81·90	·007	·014	·020	·027	·035	·044	·060	—	—	—	170,200 76·0	2,078	133·6	131·1	Visibly cracking at 170,200 lb. (76·0 tons).
1015	See *Fig.* 6, on next page	72·68	81·90	·010	·018	·026	·033	·040	·050	·066	—	—	—	163,700 73·1	1,999	128·6		Visibly cracking at 163,700 lb. (73·1 tons).

Particulars of composition and reinforcement, etc., are taken from Mr. F. Woodward's letter of March 4th, 1900. Initial stress, 20,000 lb. Ends of the columns were prepared true here for testing. All the columns failed by crushing at about 1 to 2 ft. from end. All tests March 30th.

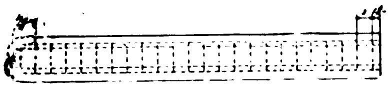


Fig. 1. $\frac{3}{16}$" Binding Ties spaced 3" × 6½" apart.

Fig. 2. Do.

	Weight	Marked
9·02" × 8·99"	565 lb.	D
9·04" × 9·01"	560 lb.	D1

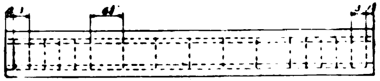


Fig 3. $\frac{3}{16}$" Binding Ties spaced 3" apart

Fig. 4. Do.

	Weight	Marked
8·97" × 8·99"	547 lb.	E
9·06" × 9·03"	562 lb.	E1

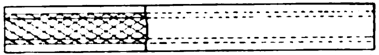


Fig. 5. Binding: Expanded Metal 2'-9" wide, 1½" mesh, $\frac{1}{8}$" × $\frac{1}{8}$" strand, in two lengths 3'-0" × 3' 3" long, 3" lap in centre (expanded metal tied in places with single wire)

Fig. 6. Do.

	Weight	Marked
9·04" × 9·06"	560 lb.	F
9·00" × 9·10"	568 lb.	F1

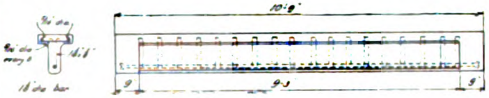
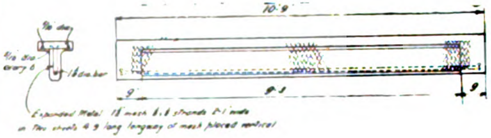
Results of Experiments by D. Kirkaldy & Son to Ascertain the Resistance to Depression under a Gradually Increased Thrusting Stress of Concrete Columns, received per Mr. F. Woodward, Clerk of Works, General Post Office Extension.

Test No.	Description	Length	Base Area	Stress in Pounds. Depression, inch, at							Ultimate Stress			Remarks
				40,000	60,000	80,000	100,000	120,000	140,000	160,000	Total	Per sq. in.	Per sq. ft.	
		in.	sq. in.								lb. tons	lb.	tons	
RR	Made May 1st. Concrete mixed fairly dry in the following proportions · 1 yd. screened Thames ballast (crushed to pass ¾" mesh), ½ yd. Thames sand, 6 cwts. Portland cement													
2834	Weight, 486 lb.; mean size, 8·99" × 9·02"	72·40	81·09	·008	·017	·027	·038	·052	—	—	136,700 61·0	1,686	108·4	Crushed (about 2" from one end)
2833	Weight, 273·4 lb.; main size, 9·00" × 9·01" This column being damaged, two shorter specimens were prepared from it, each portion being kept as long as possible	40·54	81·09	·006	·013	·020	·028	·036	·053	—	140,800 62·9	1,736	111·6	Crushed (about 18" from one end)
2833	Weight, 194·8 lb.; mean size, 8·90" × 8·97"	30·00	79·83	·004	·009	·014	·019	·025	·038	—	141,300 63·1	1,770	113·8	Crushed (about mid length)

Particulars of composition taken from Mr. Woodward's letter of July 7th, 1909. Initial Stress 20,000 lb. Ends of columns were prepared true here for testing. All tested July 22nd.

Results of Experiments by D. Kirkaldy & Son to Ascertain the Resistance to Deflection under a Gradually Increased Bending Stress of Four Reinforced Concrete Beams, received per Mr. F. Woodward, Clerk of Works, General Post Office Extension.

Load applied at centre.

Test No.	Description	Dimensions	Span	Stress in Pounds, Deflection, inch, at 4,000	6,000	8,000	10,000	12,000	14,000	16,000	Ultimate Stress	Remarks
RR	Made Jan. 14th. Concrete was mixed fairly dry in following proportion: 1 yd. screened Thames ballast (crushed to pass ¾" mesh), ½ yd. Thames sand, 6 cwts. Portland cement; machine mixed	in.	ft.								lb. tons	
1016	Marked XHB 	3·36" 12·40" 13·41" 3·34" 4·35"	10	·037 Set	·079	·123	·168 ·02	·217 ·04	·269	—	15,970=7·13	At 12,000 lb. slight hair cracks were observed on under side. At a deflection of 1", crack at centre, extended through beam to top of decking. Removed when deflection reached 5"
1017	XI	3·60" 12·02" 13·68" 3·50" 4·38"	10	·038 Set	·077	·118	·166 ·02	·219 ·04	·281	—	15,728=7·02	Ditto
1018	YHBEM 	3·35" 12·15" 13·52" 3·30" 4·30"	10	·035	·080	·125	·169	·216	·268	—	15,140=6·76	No visible cracks at a load of 14,000 lb. Removed when deflection reached 6"
1019	YI EM	3·52" 12·25" 13·62" 3·49" 4·24"	10	·035 Set	·072	·109	·149 ·02	·190 ·03	·240	·291	16,276=7·27	At 12,000 lb. slight hair cracks were observed on under side. At a deflection of 1" three main cracks about centre, extended through beam to under side of decking. Removed when deflection reached 5"

Particulars of composition and reinforcement, etc., are taken from Mr. F. Woodward's letter of March 4th, 1909. Initial stress 2,000 lb. **All tested April 1st.** Beam Test No. RR 1018 was tested first, after which it was decided to take the set deflection.

RESULTS OF EXPERIMENTS BY D. KIRKALDY & SON, TO ASCERTAIN THE RESISTANCE TO THRUSTING STRESS OF EIGHTEEN CUBES OF CONCRETE, RECEIVED PER MR. F. WOODWARD, CLERK OF WORKS, GENERAL POST OFFICE EXTENSION.

Test No.	Description	Weight	Dimensions		Base Area	Crushed			
						Stress	Per sq. in.	Per sq. ft.	
	Composition: 1 yd. crushed Thames ballast to pass ¾" mesh, ½ yd. Thames sand, 7 cwts. cement	lb.	in.		sq. in.	lb.	lb.	tons	
PP	Age nearly 2 months (7 weeks, 5 days)								
5734*	Marked D	5·65	4·00	3·98 × 4·04	16·08	30,875	1,920	123·5	114·4
5733*	Marked D. Oct. 25th, 1907	5·63	4·01	3·98 × 4·02	16·00	29,075	1,817	116·8	
5732*	Marked D. Oct. 25th, 1907	5·67	4·04	4·00 × 3·98	15·92	25,500	1,602	103·0	
5737*	Marked W.	5·44	4·00	3·90 × 3·98	15·52	33,250	2,142	137·7	130·6
5735*	Marked W	5·57	4·00	3·98 × 3·94	15·68	31,650	2,018	129·8	
5736*	Marked W	5·60	4·02	3·94 × 4·00	15·76	30,475	1,934	124·4	
QQ	Age 6 months—								
1734†	Marked D. Oct. 25th, 1907	5·22	4·00	4·00 × 3·97	15·88	59,900	3,772	242·6	229·2
1733†	Marked D. Oct. 25th, 1907	5·27	4·03	4·01 × 4·00	16·04	56,650	3,532	227·1	
1735†	Marked D. Oct. 25th, 1907	5·36	4·04	4·02 × 4·01	16·12	54,600	3,387	217·8	
1736†	Marked W. Oct. 25th, 1907	5·26	3·93	4·05 × 4·01	16·24	53,500	3,294	211·8	203·7
1737†	Marked W. Oct. 25th, 1907	5·24	3·95	4·07 × 4·02	16·36	51,000	3,117	200·4	
1738†	Marked W. Oct. 25th, 1907	5·20	3·95	4·00 × 4·00	16·00	49,450	3,091	198·8	
RR	Age 18 months—								
1818‡	Marked D	5·41	4·01	4·05 × 4·01	16·24	68,640	4,227	271·8	268·0
1820‡	Marked D	5·40	4·01	4·03 × 3·99	16·08	67,440	4,194	269·7	
1819‡	Marked D	5·24	4·00	3·99 × 3·96	15·80	64,500	4,082	262·5	
1822‡	Marked W	5·12	3·97	4·04 × 3·92	15·84	54,960	3,470	223·2	212·2
1821‡	Marked W	5·38	4·11	3·99 × 3·98	15·88	52,260	3,291	211·6	
1823‡	Marked W	5·27	4·04	4·04 × 3·96	15·84	49,680	3,136	201·7	

Bearing surfaces prepared true.

NOTE.—Cubes marked "D" were mixed fairly dry. Cubes marked "W" were more sloppy.

* Report No. 3, dated Dec. 18th, 1907. † Report No. 7, dated April 25th, 1908.

‡ Report No. 18, dated May 3rd, 1909.

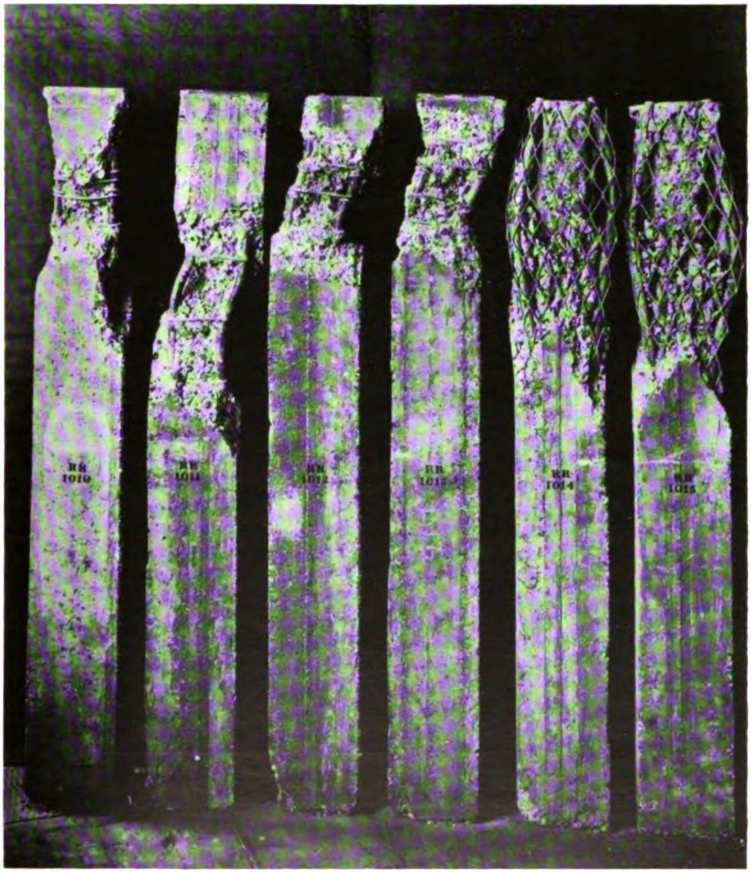


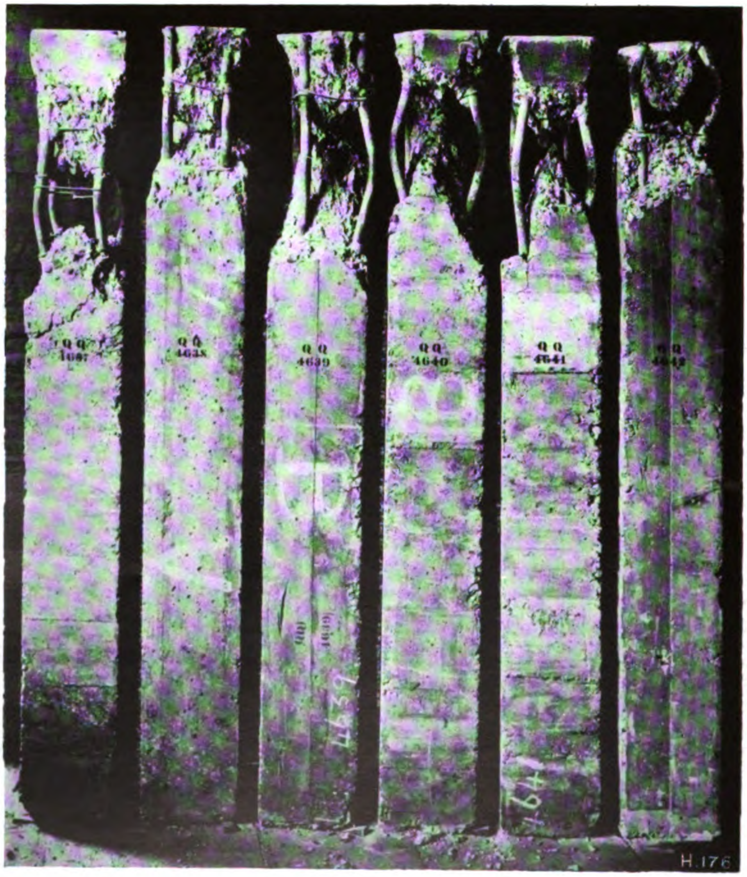
FIG 5. VIEW SHOWING FRACTURES OF REINFORCED CONCRETE COLUMNS.
(Tested for the new General Post Office.)

RESULTS OF EXPERIMENTS BY D. KIRKALDY & SON TO ASCERTAIN THE RESISTANCE TO THRUSTING STRESS OF SIX 8-INCH CUBES OF CONCRETE, RECEIVED PER MR. F. WOODWARD, CLERK OF WORKS, GENERAL POST OFFICE EXTENSION.

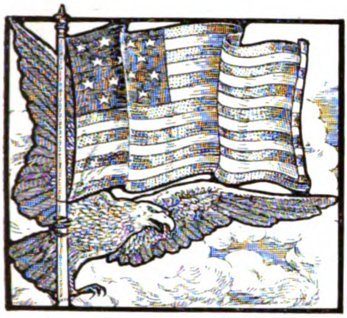
Test No.	Description	Weight	Dimensions		Base Area	Crushed			
						Stress	Per sq. in.	Per sq. ft.	
		lb.	in.		sq. in.	lb.	lb.	tons	
	Composition : 1 yd. crushed Thames ballast to pass ¾″ mesh, ½ yd. Thames sand, 7 cwt. cement								
QQ 1213*	Age 2 months	42·26	8·00	7·85 × 8·00	62·80	219,500	3,495	224·8	212·0
1215*	Ditto.	42·63	8·02	7·85 × 8·00	62·80	205,000	3,264	209·9	
1214*	Ditto.	42·17	8·02	7·84 × 8·00	62·72	196,300	3,130	201·3	
	Composition : 1½ yd. Thames sand, 7 cwt. cement								
2729†	Age 3 months	38·98	8·03	8·01 × 7·92	63·44	141,500	2,230	143·4	144·0
2730†	Ditto.	38·11	8·03	8·05 × 7·90	63·59	141,900	2,231	143·5	
2731†	Ditto	39·35	8·07	8·01 × 7·96	63·76	144·000	2,258	145·2	

Bearing surfaces prepared true.

* Report No. 4, dated Mar. 25th, 1908. † Report No. 8, dated July 14th, 1908.



VIEW SHOWING FRACTURES OF REINFORCED CONCRETE COLUMNS.
(Tested for the new General Post Office.)



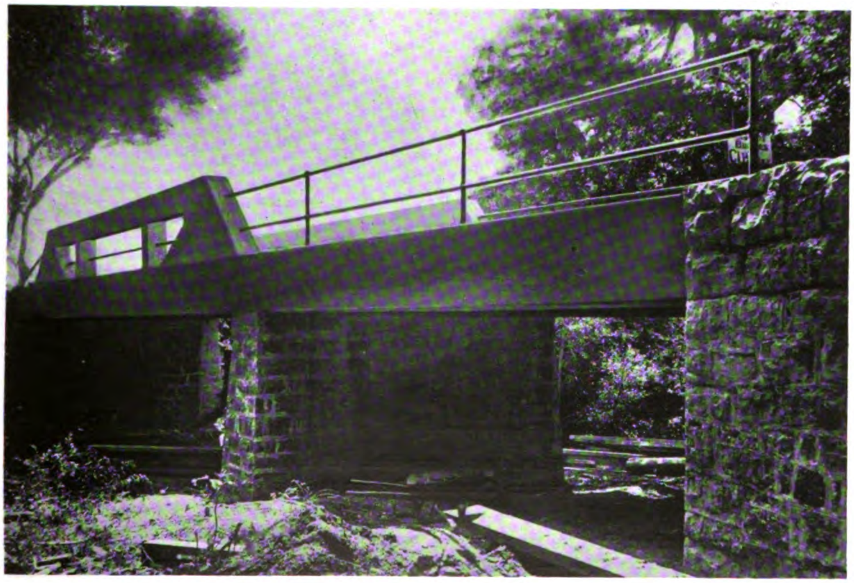
SOME RECENT WORKS IN REINFORCED CONCRETE IN THE UNITED STATES.

The particulars in this article show some interesting new works in reinforced concrete which have recently been completed in the United States. The description of the Pennsylvania Filtration Plant is worthy of special attention, as it shows how reinforced concrete can be effectively applied to this class of work.—ED.

CONVERTING A STEEL BRIDGE INTO A REINFORCED CONCRETE BRIDGE.

THE County Commissioners, the governing board of public affairs, of Cowley County, Kansas, have for several years been building stone and concrete bridges exclusively.

The bridge described in this article was a small steel span, with 28 ft. of wood trestle approach, and was an uncompleted link in a chain of permanent structures between the town of Rock and Winfield, the county seat.



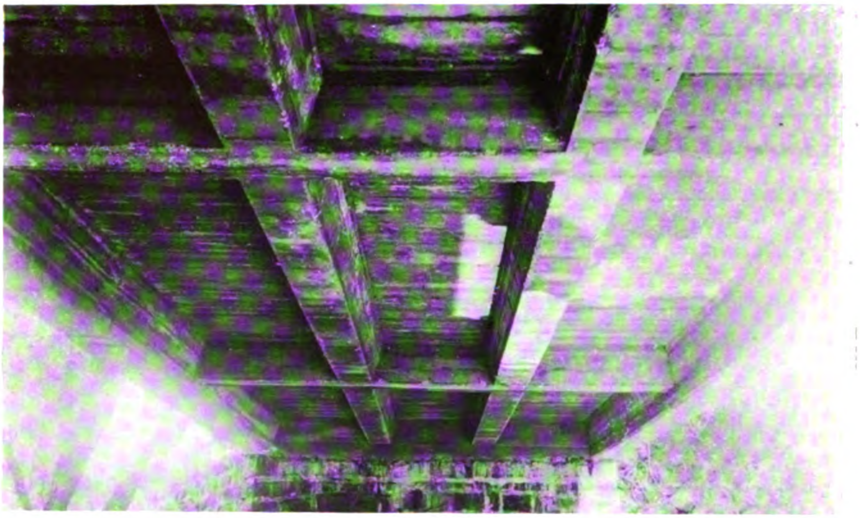
View of completed bridge

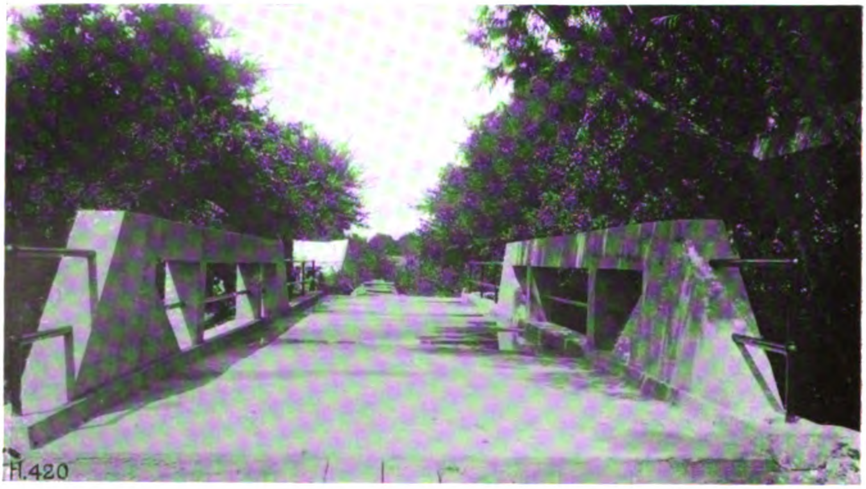
REINFORCED CONCRETE BRIDGE IN KANSAS, ORIGINALLY A STEEL STRUCTURE.

Messrs. Hughes & Hammond, engineers of Kansas city, were requested to make an examination of this structure to see if some means could not be devised to put a concrete floor on the steel span and a concrete approach span on the end.

On examination it was discovered that the steel members were too light to carry the increased load from a concrete floor, and, as no way to reinforce the same seemed practicable, except that it be used as a nucleus for a concrete girder, this was suggested to the Commissioners, and, as it met with their approval, the design was made, and, on account of the unusual features of the work, contract was taken on cost, plus 10 per cent. for tools and engineering expense.

View of main span floor system, from underneath.

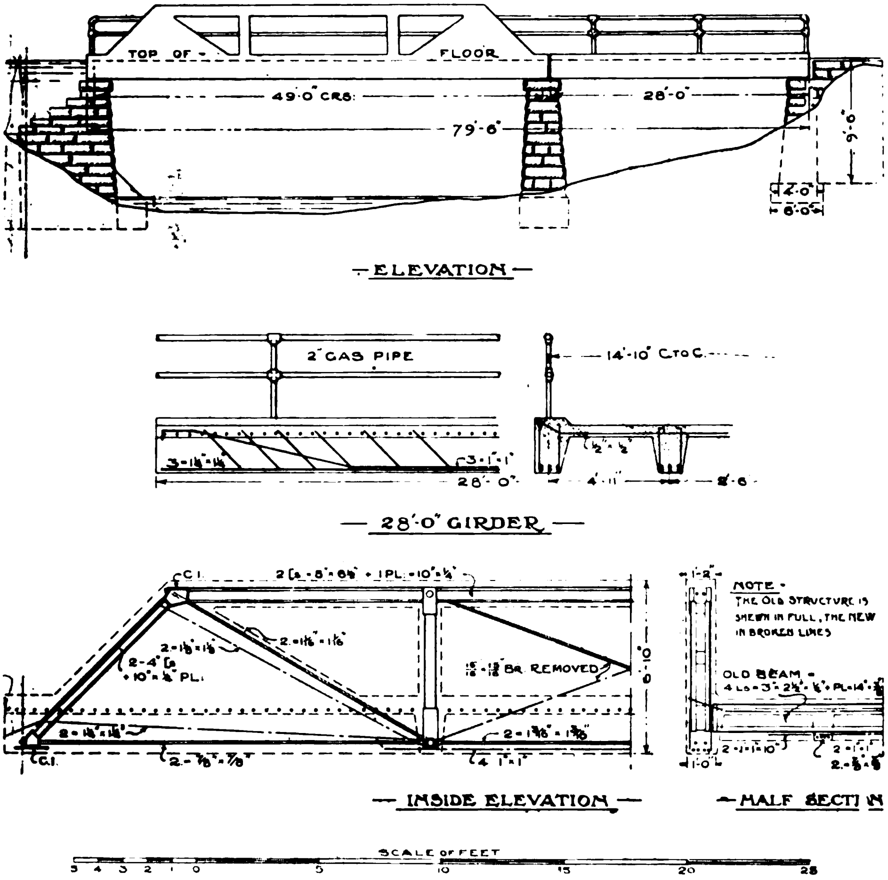




End view of completed bridge.
Reinforced Concrete Bridge in Kansas.

One new masonry abutment was constructed on the approach end, and others were repointed and repaired. Forms were constructed, encasing the entire steel bridge and approach as seen in illustration on page 188.

The structure had to be taken down and all steel work was cleaned of rust, and, after abutments and piers were repaired, was re-erected and the additional reinforcement placed and carefully wired in position. The forms were constructed of 1-in. dressed sidings and 2-in. x 4-in. and 2-in. x 6-in. braces through, so as to prevent bulging, due to weight of wet concrete. The mixture was made very wet, what is generally designated as "sloppy" so that it would pour easily, and was thoroughly tamped. When forms were removed the surface showed no pockets, which is so noticeable on work where the concrete is mixed too dry and care was not taken to tamp and cut the outside next forms to permit the concrete to flush and fill all voids.



General elevations and detail sections.

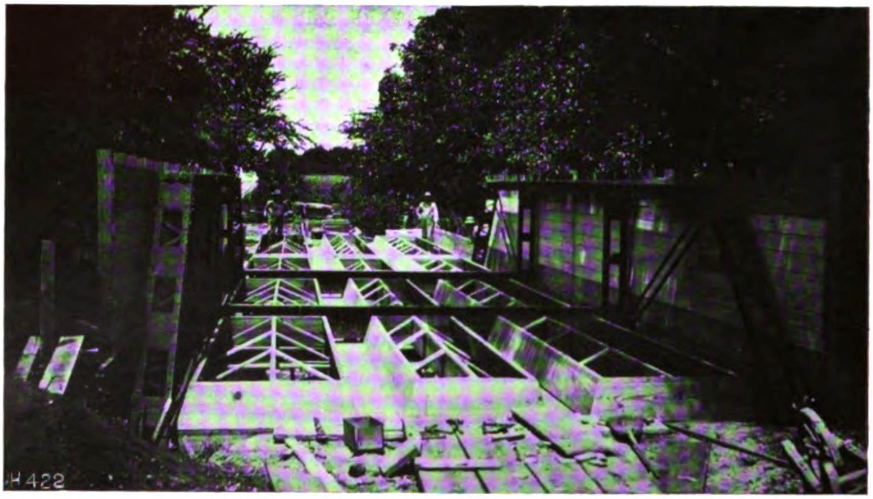
Reinforced Concrete Bridge in Kansas.

The cost for this bridge was about two-thirds of the cost for a new concrete structure having the same dimensions, which are a 50-ft. bridge span, an approach of 28 ft. 9 in., and a road bed 14 ft. wide.

REINFORCED CONCRETE ON THE BOSTON ELEVATED RAILWAY.

The Forest Hill extension of the Boston Elevated Railway, which has recently been completed, presents some unusual features of treatment, and reveals something of the possibilities of concrete for concealing the customary unsightly features of this class of construction.

For most of its length of over two miles this extension follows in general the ordinary type of steel elevated structure. Where, however, it crosses the Arborway, a broad boulevard and parkway, a treatment more in conformity with the nature of the surroundings was demanded. This led to the construction of a section 372 ft. long, of the peculiar type here illustrated and described.



Outside forms for the main girders in place.

Reinforced Concrete Bridge in Kansas.

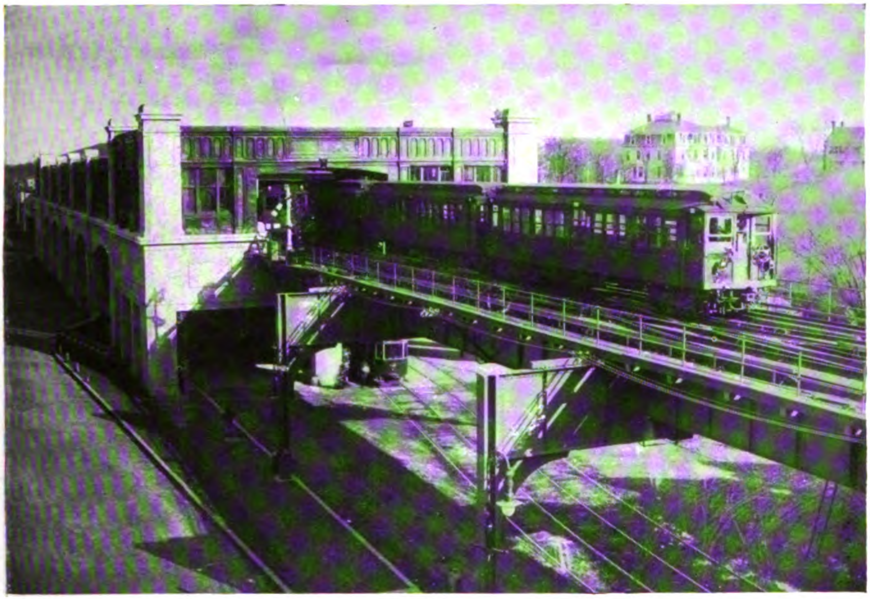
This section gives the appearance of girder spans of concrete masonry resting on centre piers of concrete—a design unique in elevated railway construction. This result has been effected by a radical modification of the columns and transverse girders and by enclosing all of the steel work with reinforced concrete relieved by exterior mouldings and provided with a solid ballasted floor between sidewalks protected by parapet walls.

The Arborway spans are alternately 45 ft. and 64 ft. long, and are supported by column-like piers in the centre line of the viaduct. These piers carry double cantilever transverse girders which support the tracks.

The essential construction of the pier is a rectangular steel tower with a transverse base sufficient to provide a satisfactory moment of stability under the eccentric, unbalanced train loads it supports. The towers, 20 ft. high, have a rectangular base 5 ft. 7 in. wide, and 8 ft. 8 in. long over all, transverse to the axis of the viaduct. This base is made with two separate 2-ft. 8-in. × 5-ft. 7-in. pedestals, each of which receives two vertical columns and is anchored by four 1⅜-in. bolts.

The structural steel is entirely enclosed in solid concrete of a minimum thickness of 3 in., reinforced with rods ¼ in. in diameter and upwards to strengthen it and anchor it to the steel work. The lower flanges of the longitudinal girders are connected in the outside panels by a horizontal concrete ceiling 3 in. thick; in the centre panel the ceiling slab is considerably depressed at the piers and slightly curved

Another entrance to station, showing ordinary type of steel elevated structure.

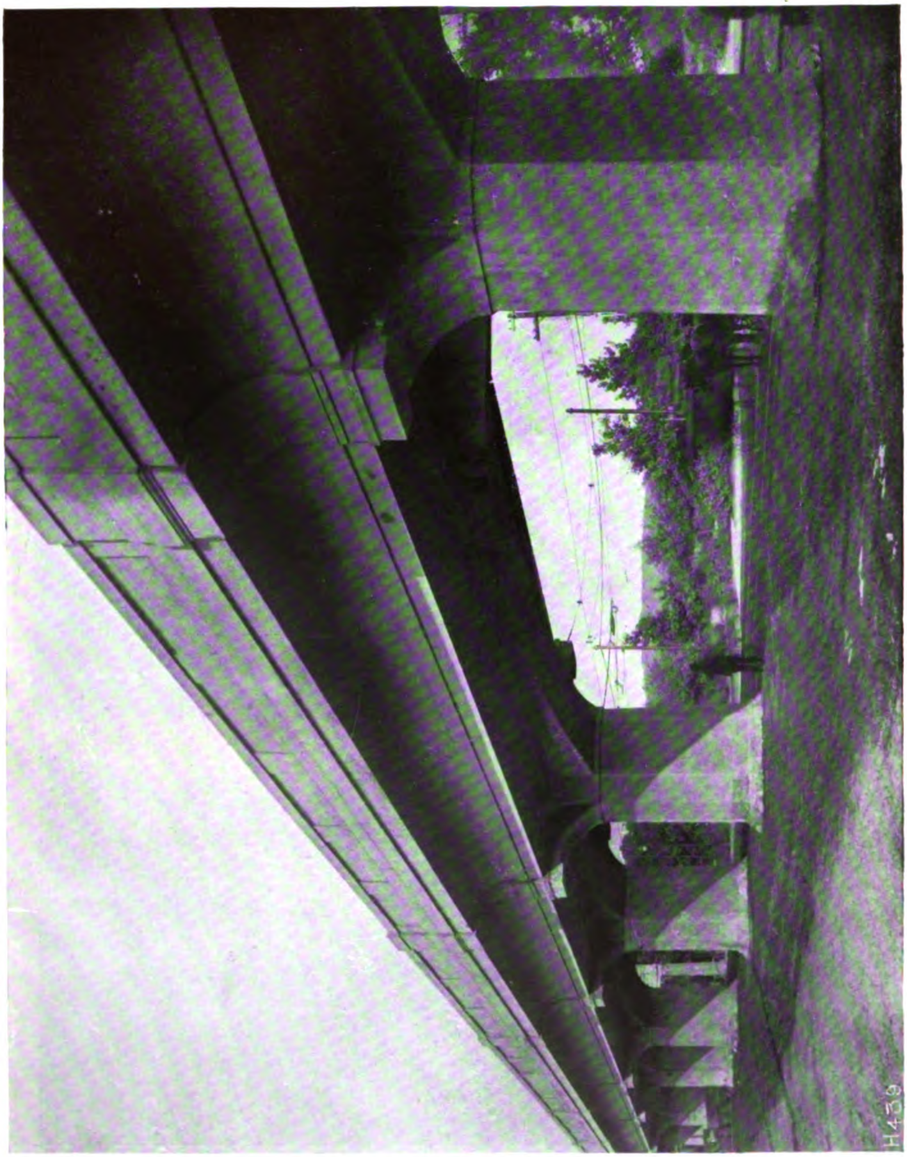


View showing junction of station and Arborway—rails enclosed by concrete covering.

BOSTON ELEVATED RAILWAY

in longitudinal section to make a false arch soffit conformable to the general design of an imitation solid masonry structure.

The top flanges of the longitudinal girders support a continuous reinforced concrete floorslab 8½ in. thick, with a clear transverse span of about 5 ft., which is 27 ft. 4 in. wide over all. The lower flanges of the steel fascia girders are connected with the lower flanges of the outside longitudinal girders by a continuous longitudinal concave-concrete fascia slab 3 in. thick, which is quadrant shape in cross section and really forms a deep cornice moulding under the sidewalk.



Reinforced concrete structure covering the steel rails.
BOSTON ELEVATED RAILWAY.

At the piers the concrete construction is rather complicated owing to the elaborate character of the girders, diaphragms, and other members connected there, and to the provision for longitudinal movement at the expansion joints. The four columns of each pier are enclosed in an octagonal mass of concrete 8 ft. 4 in. in diameter, which forms a shaft.

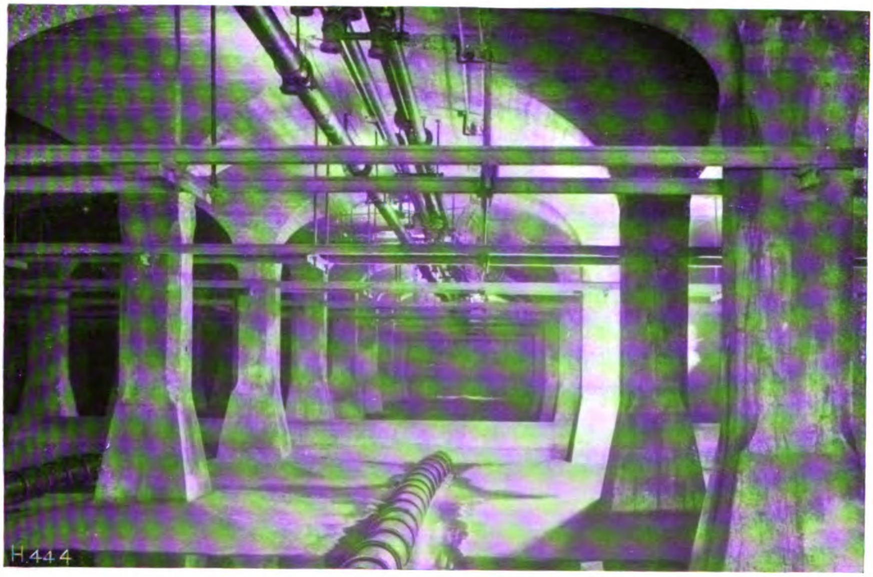
Although the pier concrete possesses considerable strength as a column it is not designed to carry any vertical load except its own weight, and has neither reinforcement bars nor anchorage except as it is interlocked with the flanges of the steel columns. The concrete extends from the ground to the lower flanges of the transverse girders, and the slightly-battered faces are relieved by a base course protected by reinforced concrete fenders at the angles and by rectangular mouldings at the top, where it joins the false arch soffit and the concave surfaces enclosing the knee-braces.

Temperature movements are provided for at each pier by open transverse-expansion joints with a normal clearness of 1 in. through the concrete floor. The sidewalks, 3 ft. wide, have reinforced-concrete curbs. The space between each of them and the floorslab is utilised by twelve rectangular conduits for electric wires.

CONCRETE FOR THE PITTSBURG FILTRATION PLANT.

Concrete is being used almost exclusively in the construction of the new Pittsburg Filtration Plant at Aspinwall, Pennsylvania. Ten new filters, each covering an acre, are being added to the old plant to supply the city of Alleghany with filtered water, the floors, roof, roof columns, dividing walls between filters, and most of the conduits being of concrete.

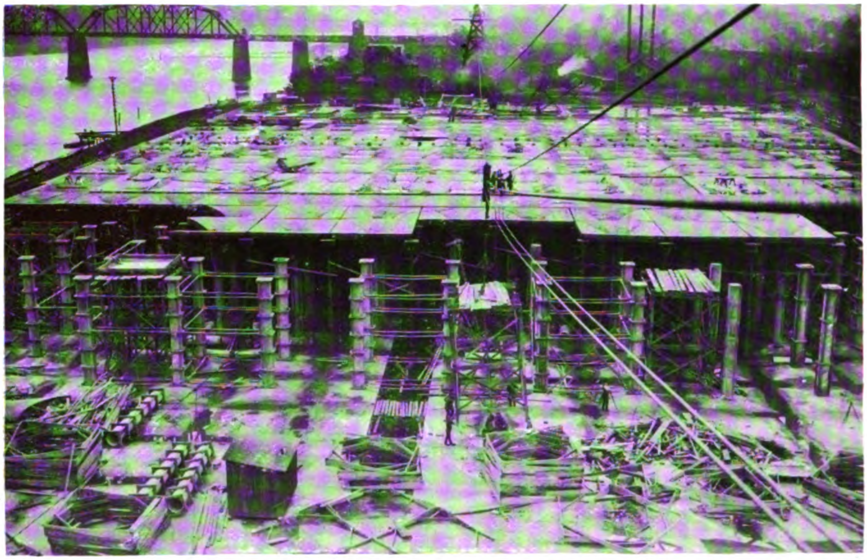
The bottom and inside slopes of the basin have a concrete lining 6 in. thick, and, for further protection against frost and wave, the inside slopes between high and low water levels are provided with concrete revetment slabs 7 ft. square and 12 in. thick, laid upon a bed of gravel 18 in. in depth.

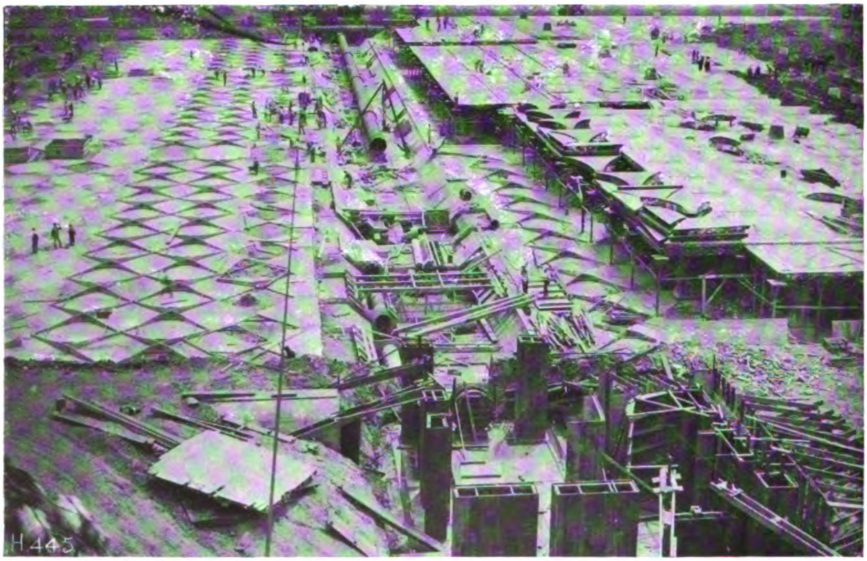


Interior view of filter.
PITTSBURG FILTRATION PLANT.

The filters and galleries are of the usual concrete construction with a groined arch roof supported on concrete piers, spaced 15 ft. centre to centre, the whole being covered with 3 ft. of soil for protection during cold weather.

General view, showing floor, columns and roof.

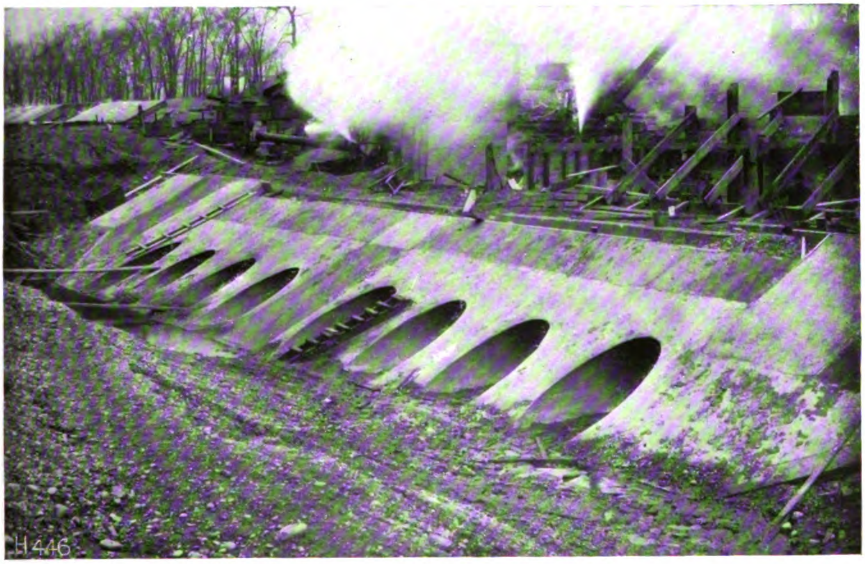




View of galleries and filters, showing roof.
Pittsburg Filtration Plant.

On this page we give a general view of the work, showing floor, dividing walls, columns and roof, all of which are of concrete. The movable cableway used to convey the concrete is also seen.

There are forty-six filters in all, with a net area of one acre each. The filters are 163 ft. × 263 ft. in plan and 12 ft. high between floor and roof, which is supported by 170 concrete piers, each 22 in. square.



View of concrete intake conduits.
PITTSBURG FILTRATION PLANT.

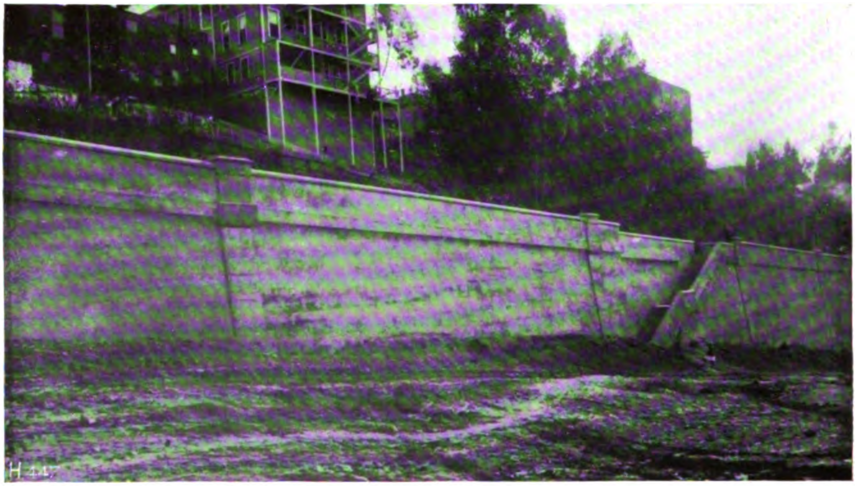
The under drainage system consists of a concrete main collector upon the floor of the middle bay and extending the entire length of the filter.

The water, which contains at times large quantities of silt and is often highly polluted, first enters a concrete intake on the river bank near the pumping station. From this point it passes through a concrete suction conduit 124 in. in diameter.

Mr. Morris Knowles, Chief Engineer of the Pittsburg Filtration Works, had charge of this work, and the progress made on the job is remarkable, and it is expected that the contract will be finished long before the date set for completion.

IMMENSE CONCRETE RETAINING WALL.

The wall and parapet on Third and Hope Streets, Los Angeles, a part of which we show in our illustration and which has just been completed for the city at a cost of $19,000 (£3,400), is a monument of concrete. The wall has a length of 600 ft. and is 52 ft. 8 in. high at maximum height, with a minimum of 13 ft.



View of portion of retaining wall.

IMMENSE CONCRETE RETAINING WALL AT LOS ANGELES.

The expanse of the wall is broken midway with a staircase of about 100 steps, which complicated the construction. The wall is surmounted by a 5-ft. parapet. The foundation at maximum height of wall is 14 ft. wide; the wall ranges in width from 8 ft. 1 in. to 3 ft. wide at the base of the parapet. Upwards of 3,000 barrels of Portland cement were required in the construction.

The specifications called for construction in 40-ft. sections, no two adjoining sections to be constructed simultaneously. Alternating expansion and contraction joints are provided for. The section method of construction required frequent removal of the contractor's plant and two sets of workmen were employed, one for mixing and spreading concrete, the other on the forms and back-filling the wall with a 6-in. layer of coarse gravel. The concrete of one section was allowed to set before another section was begun.

At the upper end, where the height is not so great, a wooden trough was used on account of the greater ease and quickness in moving it. At the lower end of the wall, where the aggregate must be run greater distances, the concrete was conveyed from the mixer through the iron pipe and placed where needed in the forms by a movable short trough. In this manner the concrete was sometimes conveyed 100 ft. and more. It was carefully spread and tamped.

The expansion and contraction joints alternate, a distance of 80 ft. existing between two expansion joints or two contraction joints. The expansion joint is made by nailing sheeting across the end of the section and properly bracing the same. The expansion joints are reinforced with pilasters.

The contraction joints were formed midway between the pilasters by bringing the end of one section of the wall up to a true vertical plane at a right angle with the central line of the wall.

The concrete of one section was allowed to set before the other section was begun, as noted, and the forms were demoved as soon as the concrete was set sufficiently to stand, and the exposed face of the wall was given the proper amount of moisture and covered to a depth of ¼ in. with a coat of plaster composed of 1 part cement to 1½ parts of clean, sharp sand. Before applying the plaster coat the surface of the concrete was thoroughly cleaned and covered with neat cement powder, the mortar coat being applied immediately after. All exposed surfaces of the concrete, except that of the parapet wall below the caps, were brought to a smooth surface by using wooden floats. The surface coat of each section required to be completed in one day.

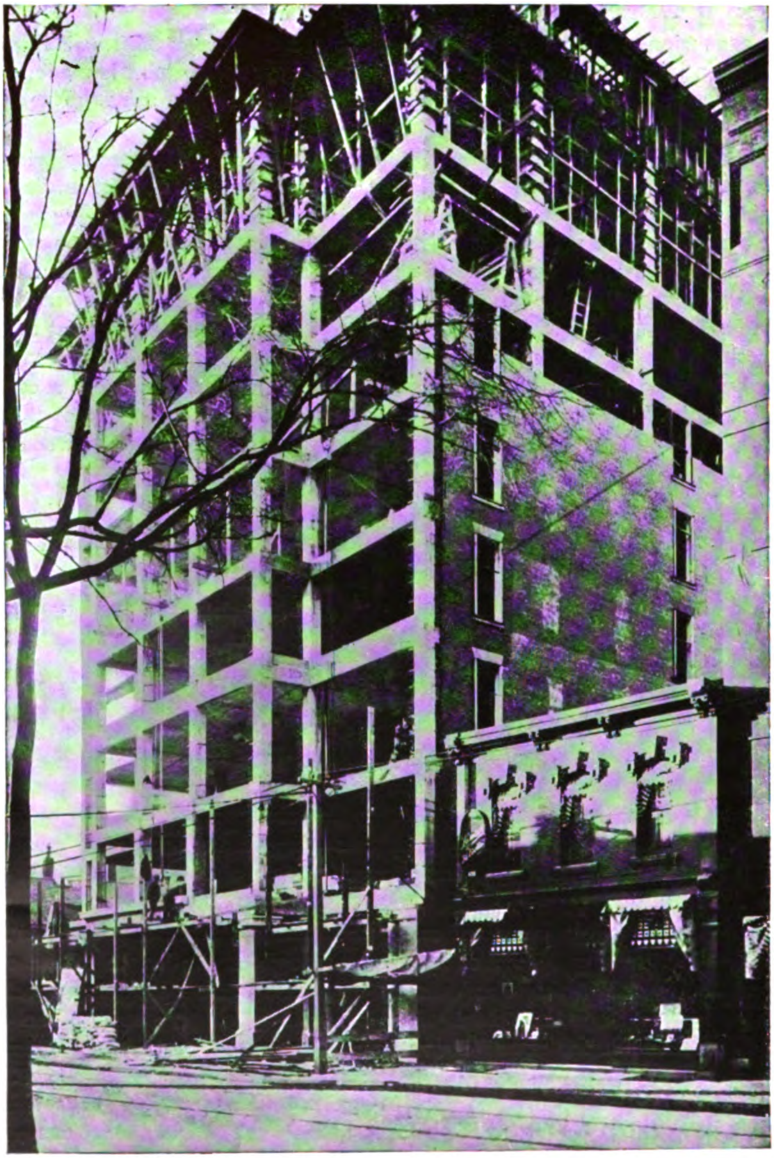
EIGHT-STORY REINFORCED CONCRETE BUILDING AT PORTLAND, MAINE.

The eight-story building described in this article was recently erected at Portland, Maine, a reinforced concrete frame being used, with flat slab reinforced concrete floors and brick walls. These walls had a total thickness of 12 in., 4 in. being outside the reinforced concrete frame and the remainder resting on the beams. The stairs throughout the building are of concrete, veneered with marble and terrazza.

The columns were mixed of unusually rich concrete—one part cement, half part sand and two of crushed stone. This gave a very hard concrete. Embedded in the columns are vertical steel bars. The ends of these are milled so as to give an even bearing from one to the other and aligned by the use of a short length of iron pipe. Around these are steel hoops, 2 in. by ½ in. thick, lapped and secured by two U-bolts; and on the lower floor there is a large cross section of steel, besides the concrete carrying the load.

The columns in the basement and on the first floor have their reinforcement hooped together, the hoops being spaced 12 in. apart throughout the length of the columns. Those on the remaining floors are secured against flexure by bands encircling the reinforcement along the middle third of their length only. The tops of the columns flare, and steel bars, which extend down the column inside the steel hoops, branch off from the columns and are joined together by horizontal hoops at the floor level. When the concrete is in place this arrangement of steel reinforcement acts like a mushroom spread footing built upside down. Over these heads steel bars run three ways, so that every part of the floor slab has a mat of steel at the bottom carrying the weight to the columns.

At the second floor level cast-iron saddles or spiders are used to make continuous the column reinforcing. The floor slabs are 7 in. thick for the first floor and 6 in. thick for floors above. Plaster is applied directly to the underside of these floors, this does away with lathing, and, as there are no beams, it saves in the total height of the building. For final floor surface, screeds bedding in cinder concrete rest on the floor slab, and across these is nailed the finish floor. The electric light ducts and plumbing

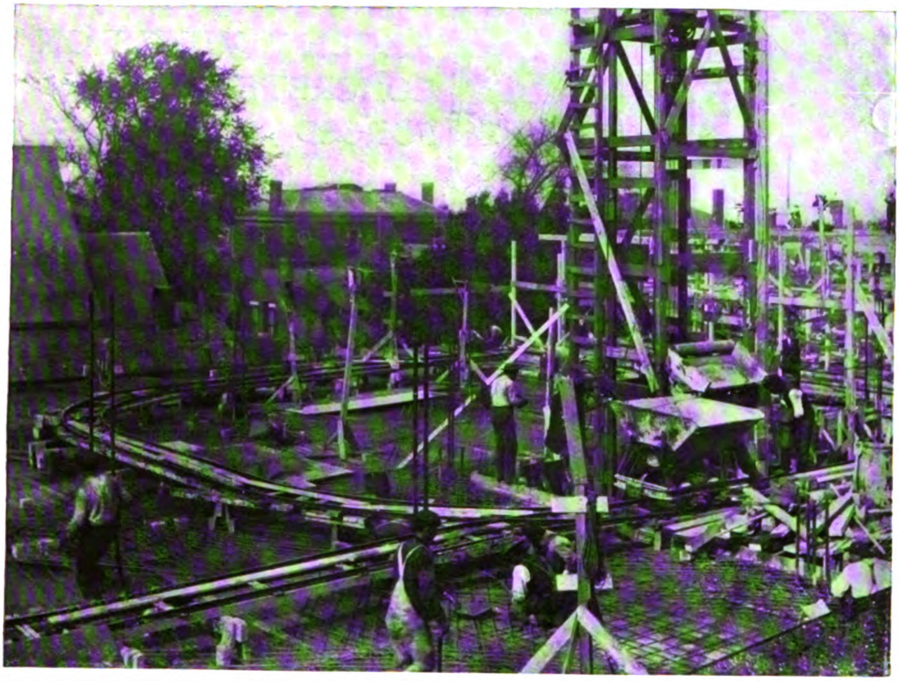


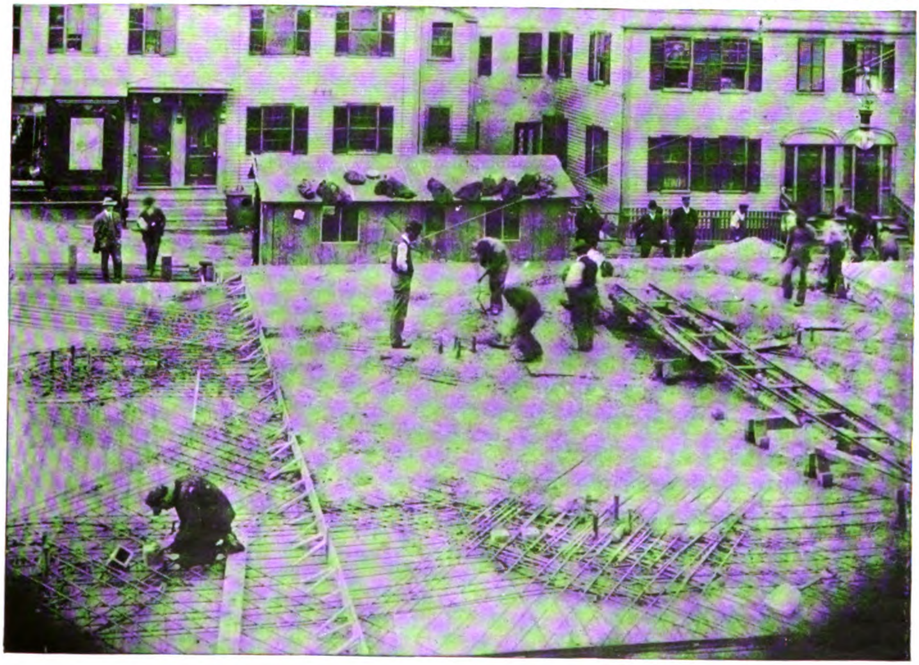
The building nearly completed.
EIGHT STORY REINFORCED CONCRETE BUILDING AT PORTLAND, MAINE.

run under this wooden floor. There are two electric passenger lifts and a freight lift with entrance at the rear.

We are indebted to the *Cement Age* for our illustrations of this building.

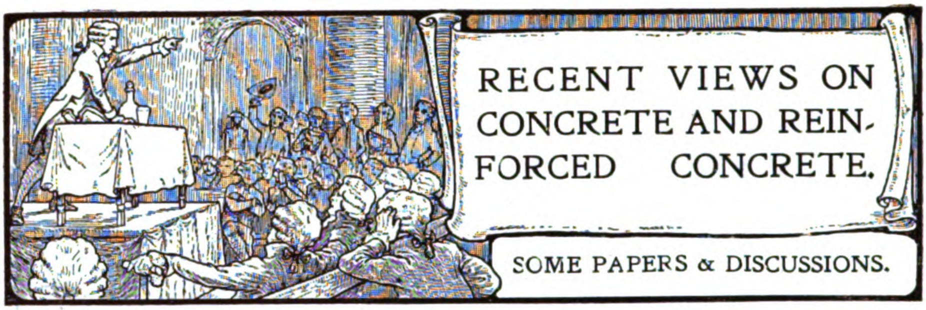
View of lift and tracks.





Laying reinforcement for first floor.

REINFORCED CONCRETE BUILDING AT PORTLAND, MAINE.


RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.
SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE LIVERPOOL ARCHITECTURAL SOCIETY.

REINFORCED CONCRETE AND STEEL FRAME BUILDINGS.

By MR. F. E. G. BADGER, Deputy City Building Surveyor, Liverpool.

Mr. F. E. G. Badger read a paper on "Reinforced Concrete and Steel Frame Buildings" before the Liverpool Architectural Society in November of last year.

At the end of the lecture Mr. Badger showed some very interesting lantern slides illustrating some of the works of a few of the reinforced concrete specialist firms, and also went into the prices of certain steel frame buildings, giving diagrams of the extent of the buildings.

THE Lecturer began by stating that the Building Regulations in force in the principal towns in the United Kingdom had been a great obstacle to the proper development of this method of construction, but a reformation was quickly taking place, and many towns had followed in the footsteps of Liverpool and obtained Parliamentary powers to relax or modify the provisions of the building regulations. Formerly it must have been very annoying to architects to be compelled to make the outside walls—which were merely acting as a curtain to keep out the weather, and which were not carrying any floor loads—of the full thickness of brickwork required by the schedule. This course involved not only an additional cost on the building owner, but in the case of a large building reduced the available floor space.

Steel.—Considering first the mere material, it might be said that unless proper precautions were taken steel had two very undesirable characteristics: first, a loss of effective area of metal due to oxidation, and second, complete inability to sustain itself when subjected to the temperature of ordinary fires. With regard to the first characteristic, there was practically no limit to the life of steel provided it was designed in such a way as to admit of thorough scraping and painting periodically.

With reference to the behaviour of steel when subjected to fire, most of them were familiar with the extraordinary shapes which steel could assume during a serious fire, especially when the metal was loaded, but there was little risk of failure provided the girders and columns were completely encased with a proper thickness of some fire-resisting casing of, say, cement, brickwork, concrete, fireclay, or other suitable material. Local authorities could generally require some suitable fire-resisting covering in public buildings, but this practice should be extended to large private buildings.

If the steel was properly encased, say in concrete or cement, it would serve the double purpose of protection from fire and oxidation, as cement is well known to be one of the best preservatives of steel. In this case the steel must on no account be painted or oiled, as the cement would not adhere. The rolling mill bloom should be carefully scraped off the girders, but a very slight amount of rust was not objectionable, in fact it was an advantage, as the cement seemed to combine chemically with the oxide of iron.

Reinforced Concrete.—It was reinforced concrete, however, that would occupy attention in the future.

The comparatively slow development of reinforced concrete in this country was chiefly due to the disasters which had befallen some of the buildings in this material in America, but the inquiries afterwards instituted into the causes of the collapse had generally proved that a total disregard of the ordinary precautions during the building had been observed. If shavings and pieces of wood were carelessly left at the foot of a column and concreted up disaster must be expected; also if the links or hooping were omitted from the vertical reinforcement in columns.

Another contributory cause of delay in the acceptance of reinforced concrete as a method of construction had been due to the fact that one effect of our changeable climate on a large superficial area of a reinforced concrete building was the cracks which were visible here and there in the thin walls.

Perhaps the first advantage attaching itself to reinforced concrete construction was economy. There were practically no maintenance charges, and when they considered the enormous cost to which railway companies and others were put every year for painting bridges, etc., this was a matter of supreme importance, and should not be overlooked when comparing the cost of the two styles of construction.

In the case of buildings, reinforced concrete superseded the old-time method of building the walls up from the foundations, and saved a great amount of time and consequently of money. It was no uncommon thing to witness the curtain walls being built at three or four different floors at the same time.

As for strength, it was generally recognised that reinforced concrete was well adapted to carry enormous loads, and with regard to stability he saw difficulties ahead when the time came to demolish reinforced concrete buildings for particular purposes. The authorities would probably not allow an explosive to be used.

Reinforced concrete was also adapted to withstand other dangerous influences. It would be difficult to find a better test than that of exposing it to the sulphurous fumes from locomotives, and the Austrian Society of Architects and Engineers had investigated the subject of concrete as applied to the construction of arches beneath which railway trains have been passing for periods up to thirteen years, and in one case engines had remained underneath for prolonged intervals. Careful examination demonstrated the facts that the surface of the concrete had suffered no injury, that there were no evidences of porosity, and that embedded iron was quite free from corrosion.

Matrix and Aggregates.—Only one cement was permissible in reinforced concrete —that is, the very best which could be obtained, and this must always be of such a quality as would pass the British Standard Specification.

Aggregates of one sort or another were procurable everywhere, but experience proved that for strength there was nothing to equal hard stones or granite, broken so as to pass a ¾-in. diameter ring and graded with smaller material down to about a quarter. The proportions were usually 4 : 2 : 1—*i.e.*, four parts of graded broken stone, two parts clean coarse sand, and one part cement. If broken brick was used, the old bricks should be cleaned of the mortar and plaster before placing in the crusher. Gravel made a first-rate concrete if properly proportioned, and it had often been demonstrated that round, smooth ballast gave nearly as strong a concrete as broken stone.

Mixing.— Generally speaking, machine mixing gave a more even concrete than hand mixing, and the best variety of machine was that known as a " batch " mixer— that is, one where a hopper or other suitable vessel was attached to the machine into which could be placed the correct proportions of aggregate and matrix. By turning a lever the whole of the contents of the hopper are discharged into the machine together with a measured quantity of water, and in a few minutes these ingredients are thoroughly mixed together, thereby resulting in a consistent concrete throughout the building.

For a reinforced concrete building of small dimensions, when the aggregates were mixed by hand, if the sand and cement were first of all mixed together with the proper quantity of water and the previously wetted broken stone added thereto, and the whole thoroughly combined, quite a first-class concrete would be obtained.

Experience showed that concrete used in these frame buildings should be much wetter than when required for " bulk " concrete, as it was found to be better for tamping and distributing round the steel reinforcement.

Reinforcement.—There were a tremendous number of systems to choose from, some of which were patented and others not, but there was no disputing the fact that no particular system comprised all the essentials of an ideal reinforcement. Generally speaking, each system had features in which one or two details were superior to those of other systems, and perhaps this was a good reason why they should study the matter themselves or confer with a consulting engineer, who would specify which system or combination of systems would be the most suitable for the particular purpose.

Calculations.—It was advisable in the first place to study the formulæ recommended by the R.I.B.A., and when these had become familiar there was no difficulty in applying the simpler formulæ which had been evolved by various experts. Many of the simplified formulæ contained constants and perhaps other somewhat empirical matter which, in the hands of a man of experience, were useful, but, if used by a beginner, might lead to a considerable risk of error.

Supervision.—In ordinary building construction one generally felt fairly comfortable when all plans had been approved and the contract duly signed, but in reinforced concrete work their little troubles only began with the commencement of operations. A keen eye must be kept on all departments, including centering, fixing rods, stirrups and links, mixing of concrete, taking samples, watching the setting, removing sheeting, etc. Of course, the calculations allow a reasonable factor of safety, but, notwithstanding that, the supervision must be continuous and strict.

The dull grey appearance of concrete was undoubtedly very monotonous, and the difficulty seemed to lie in adapting it so as to make it acceptable in such buildings where no great architectural treatment was required. When the leaders of the profession become familiar with the scientific principles, together with the practical construction of reinforced concrete, agreeable elevations in keeping with the conditions would be produced.

THE SOUTH WALES INSTITUTE OF ENGINEERS.

FERRO-CONCRETE.

By MR. ROBERT G. CLARK, Assoc.M.Inst.C.E.

Mr. Robert G. Clark, Assoc.M.Inst.C.E., read a paper on "Ferro-Concrete" before the South Wales Institute of Engineers at a recent meeting at Cardiff. Mr. W. D. Wight presided, and a number of lantern slides were shown of some of the more notable reinforced concrete structures in this country.

To many engineers and architects who came in contact with reinforced concrete for the first time the following doubts arose, and until some explanation or proof was forthcoming, the subject, as far as they were concerned, did not make much progress.

(*a*) Did the steel rust or deteriorate when covered by the concrete?

(*b*) Was reinforced concrete fireproof, and what proof was there of its durability?

(*c*) How did reinforced concrete stand shock, vibration and settlement?

(*d*) How did first cost and maintenance compare with ordinary building material construction?

Rusting of Steel in Concrete.—With reference to the protective properties of concrete and steel, chemists affirmed that the reason why the steel was kept from rusting was that the oxide of iron chemically combined with the cement, forming a covering of ferrite of calcium which was a good protective agent. The author had investigated the following two cases in his practice.

On the River Thames a reinforced concrete pile had to be withdrawn as the result of a very severe collision. The pile had been driven about three years to a very hard set, as it carried a heavy load. After being pulled up the pile was laid on the bank for inspection. At various places along the length of the pile the concrete was cut away and the steel exposed. In each case the steel had not the slightest signs of rust. On a pier further down the same river a reinforced concrete tie-beam, that had been in position about eighteen months, had to be cut away to make provision for a diagonal brace. The tie-beam was midway between high and low water mark, so that it had a severe test, being alternately wet and dry. On examination the steelwork was found as good as when put in, and moreover the rust had disappeared. It might easily be imagined in what condition the steel would have been if it had not been protected by the concrete. Again, at Southampton in 1898, several pile heads were cut off and thrown on the foreshore, so that they were alternately exposed to the air and covered by the tide. They were examined some seven years after by several well-known engineers, and they found that the exposed steelwork had greatly rusted and deteriorated, whereas by chipping away the concrete they found that the bars which were embedded in the concrete were as free from rust as the day that they were put in.

Fire-resisting Qualities.—The fireproof qualities of reinforced concrete were being recognised more and more, as may be witnessed from the number of very large buildings that were now being constructed entirely with this material. It had been clearly demonstrated that if the steel were covered with 1½ in. of concrete it would be absolutely fireproof.

Many tests had been carried out in which the temperature of the structure had been raised to 1500° Fahr., and then flooded with water, and the only thing to be noticed after were some fine hair cracks, no doubt caused by the rapid cooling. It was also proved that a reinforced concrete wall only 4 in. thick was ample protection from fire, as the temperature on the fire side of the wall was 1500° Fahr., and on the other side the temperature was only a few degrees above the open air. In the case of fires in buildings constructed of reinforced concrete the fire was usually confined to one room, as was the case at the warehouse of the Co-operative Wholesale Society at Newcastle-on-Tyne.

It was worse than useless to have a reinforced concrete floor supported either on cast iron or rolled steel joists, unless the cast iron or steel column was also rendered fireproof by a coating of concrete, or, what is better, reinforced concrete should be substituted.

Durability of Concrete.—The durability of reinforced concrete should not be difficult to prove, as it had already been shown that as long as the concrete covered the steel there was no need to have any fear. It was a well-known fact that concrete improved by age, and it was also known that the tensile strength and compressive strength of the cement also went on increasing year by year.

So far all tests prove that each year the strength of the concrete increases, but naturally the increase is very little, say, after ten years. The author had had the privilege of inspecting some concrete made with some of the earliest Portland cement, and the concrete resembled the hardest stone, and showed no sign of disintegration. The cement made to-day was a much better article, and it was only reasonable to expect even better results in the concrete. It might be pointed out that there were instances in which the concrete crumbled, and the author expressed the opinion that this might be traced to unsuitable materials or inferior cements.

Resistance to Shocks.—Probably the most remarkable characteristic of reinforced concrete was its ability to withstand excessive vibration and shocks without injury. A most convincing proof of this statement was the large number, running into tens of thousands, of reinforced concrete piles that had been successfully driven into ballast and other hard strata. In most cases the monkey weighed from two to three tons, and the blows came in sharp succession so as to keep the pile always on the move. Take the case of locomotives running over a bridge and subjecting it to shock, small in quantity, but frequent in action, due to the engine travelling. The bridge deflects under load and springs back as soon as the load is released without developing any cracks. The Messina earthquake also gave striking examples of the resistance of reinforced concrete to shocks. Regarding settlement it would be readily understood that reinforced concrete had a strong point here, as the whole structure was monolithic and could take tension as well as compression. Any tendency to cant sets up tension in some member which in ordinary construction made itself evident by cracks and fissures. It could be easily demonstrated that the tension bursts might be prevented by using steel rods.

Cost.—Regarding the cost, speaking generally, reinforced concrete was from 10 per cent. to 40 per cent. cheaper than ordinary construction, and this without taking into account the advantages already investigated. The first cost was the only cost, and maintenance charges, that were a constant worry and expense to engineers in charge of railways, bridges, docks, gasworks, etc., were entirely obviated.

The properties of concrete were, that it was weak in tension, strong in compression, comparatively cheap, and a reliable protective covering for steel. On the other hand, steel was strong in tension, rather expensive, and unless protected from the weather it rapidly deteriorated.

Reinforced concrete might be divided into three sections, viz.: Design, Materials, and Workmanship. As the materials were of a special quality and character it might be permissible to give them attention first.

Steel.—The steel should have a tensile strength of about 27 to 31 tons, and an elastic limit ranging from 15 to 16 tons. It should be made to stand the usual tests of the British Standard Specification as regards bending. All steel should, wherever possible, be bent cold, and if it must be heated great care should be taken that it was not warmed above cherry red. Welds should be avoided, as lapping the bars about thirty times their diameter was more satisfactory and reliable. Any loose scale should be scraped off, but the bars should not be coated with paint, oil, or cement wash. Each beam must be designed to comply with the individual conditions, which so very rarely coincide; the span, fixation, load, and position of the load are four variable factors.

Cement. This should be of the best Portland cement, complying with the British Standard Specification. It should be free from gypsum, especially for setting under water. With the modern methods of manufacture the cement of to-day was truly a scientific article, and as such demanded scientific treatment if its strength was to be brought out, as opposed to the rough-and-ready handling that it often met with at the hands of the average labourer or foreman. The author had no hesitation in stating that it was possible to get results from 50 per cent. to 100 per cent. better than ten years ago if the cement were treated properly and intelligently. The question of setting time for reinforced concrete work was often the cause of trouble, and very often the concrete had commenced to set before it had been placed in position; the subsequent ramming and tamping only served to oppose the setting of the concrete. The quantity of water used was often left to the discretion of the labourer, and varied considerably. Concrete often took a week or so before "going off," but in most cases, where it had been obtained from reliable makers, it would be found to harden all right within the specified time.

Sand. – The sand should be clean and sharp, and of various sizes from $\frac{1}{8}$ in. downwards. It should be free from shells, clay, earthy or vegetable matter. Very fine sand should not be used except as a small proportion. Fine sand gave a larger area for the cement to cover, with the result that the mixture was greatly weakened.

Aggregate.—It should be a hard stone, and where granite was easily obtainable it should be universally used. It might be urged that granite was expensive, but this difficulty fell to the ground when it was remembered that it would safely stand about twice the crushing stress that most stones crush at, and, as the same quantity would not be required, it might be regarded as economical. The sizes should vary from $\frac{1}{8}$ in. to $\frac{3}{4}$ in. This should also be free from quarry refuse and all foreign matter, and, if necessary, washed.

Water. The water should be preferably fresh water free from acids, grease, or any vegetable matter. Clean sea-water was not prohibited. In order to reduce the voids to a minimum it would be as well to make a few experiments with the proportions of sand and stone, to see which gave the best results. If all sand were used the mixture would be poor and weak, and on the other hand, if all large stone were used a rich mixture might be obtained, but it would be full of voids, and thus render the steel subject to rust. For marine work and piles the cement should be increased, say, about 10 per cent.

Mixing.—The concrete should be preferably machine mixed, but if mixed by hand, as was common on small jobs, it was a wise precaution to increase the cement. As soon as it was mixed it should be taken in small quantities to the work and well tamped in, so that it was well packed round the reinforcement.

Workmanship.– Even with the best materials and design there yet remained a most important factor that might upset all the calculations, namely, workmanship. It could not be too strongly emphasised that if it were not properly carried out and supervised very indifferent results might ensue. Contractors, foremen and workmen require special training and education in this class of work. In all cases it was advisable to have a competent supervisor, who should always be stationed on the work. He should see that the materials were up to the specification, check the sizes and number of bars in a beam, floor or column, also see that they were in the position shown in the drawings before concreting was allowed to commence. He should also see that the concrete was placed in position without disturbing the steel, and see that the tamping was done without forcing the steel out of its proper position.

All moulds, centering and shuttering should be of well-seasoned timber. The joints must be close, so as to prevent leakage, and the timbering should be designed strong enough, so that the weight of the materials did not cause the timber to unduly deflect.

Before concreting be allowed to commence great care should be taken to see that all sawdust, chips, etc., are cleared away.

The construction of beams, decking and floors had often to be interrupted before completion, and in such cases the edges of the concrete should be roughened with a cutting tool and then thoroughly cleaned from all loose and foreign matter. To this rough surface neat cement grout should be applied with a brush, and the concrete should then be immediately placed in position and rammed up to the old work.

In the case of columns there was a great saving to be derived by adopting reinforced concrete. Plain concrete was liable to fail suddenly, and it occupied an excessive amount of space. A step has been taken in the right direction by embedding rolled steel joists for columns in concrete; but this is not economical compared with reinforced concrete. Provision should be made for eccentric loading, so that the steel should be placed to the best advantage, that is, as far from centre of column as possible.

Generally.—Reinforced concrete had been applied to many, if not all, types of engineering and architectural work. What the growth of reinforced concrete would be during the next five or ten years was a matter of speculation, but the author ventured to think that it would be very much in advance of the past five years. At the present time the subject was occupying the attention of the leading engineering and architectural institutions, and there were signs that they were giving reinforced concrete their active support, even if some of the many proposed regulations were rather academical. So far the local building laws of the cities and boroughs had somewhat hampered the development within their jurisdiction, but as a general rule after the plans had been explained and inspected they had been passed. Already London, Glasgow, Liverpool and Manchester had amended their by-laws in order to comply with reinforced concrete conditions, so that in a few years doubtless other cities and boroughs would follow their lead.

IRON AND STEEL INSTITUTE.

IRON AND STEEL PRESERVATION.

Paper by MR. ALLERTON S. CUSHMAN.

At the annual meeting of the Iron and Steel Institute, held recently at Westminster, at which Sir Hugh Bell, Bart., presided, an important paper was read by Mr. Allerton S. Cushman, Assistant-Director of the United States Office of Public Roads.

Mr. Cushman pointed out the necessity for a preservation of manufactured iron and steel, in order to secure the conservation of supplies. A further interesting point was the security of modern concrete buildings reinforced with steel. If, he said, steel reinforcements rusted away, it boded ill for the future of many modern structures owing to the impossibility of making inspections and repairs before the danger point was reached. The records of discussions before a number of engineering and scientific bodies showed that there was conflicting evidence and opinion in regard to this subject. There could be no doubt that the reaction of unleashed cement concrete was strongly alkaline owing to the separation of free lime at the time of set. If this alkaline reaction was maintained, steel embedded in the concrete should remain uncorroded. If, however, as was sometimes the case, percolating waters found their way through the concrete, the free lime would eventually be removed and dangerous rusting take place. Nails and other objects of steel would remain bright when immersed in lime water, and the author had found that the addition of about 5 per cent. of quicklime to soggy, sour clays and soils would have a very decidedly protective effect on steel embedded in them. It was curious that this simple expedient had not been resorted to in order to prolong the life of steel pipes, lines trenched in soggy clay soils, where there was but little movement of soil and subsoil water.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED ARMOURED CONCRETE DOCK WAREHOUSES AT MARSEILLES.

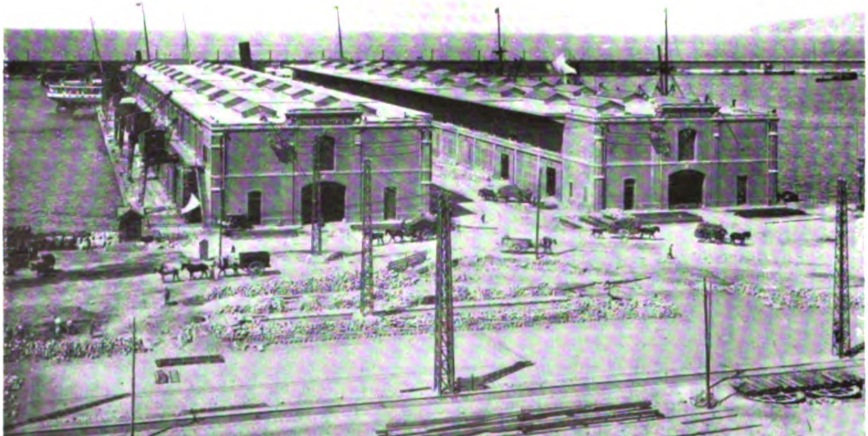
AT the beginning of the year 1906 the Chamber of Commerce of Marseilles placed in competition two dock warehouses. The scheme for these was prepared by the Marine Department.

All the principal steel contractors in France competed for this work. Owing to the fact that the other similar warehouses in the Marseilles Docks were built in steelwork, the scheme did not include reinforced concrete. The specialists in reinforced concrete were, therefore, only admitted to this competition after very careful examination of the advantages offered by this material over steelwork.

About fifteen schemes in steelwork and in reinforced concrete were examined by the Chief Engineer of Bridges and Ways, and also by the District Engineer. They decided, with the approval of the Chamber of Commerce, to place the work in the hands of Monsieur Edmond Coignet, whose scheme presented an economy over steel construction of about 200,000 francs (£8,000), and also offered the other advantages of rapidity of execution and considerable resistance to fire.

The two warehouses are built alongside the quay, and parallel to each other, each building measuring 105 ft. in width and 771 ft. in length.

Each warehouse is composed of a ground floor, paved with granite sets, and



General view of warehouses.
REINFORCED CONCRETE DOCK WAREHOUSES AT MARSEILLES.

a first floor covered with asphalt. The roof is flat and covered with water-proofing material and gravel.

Facing the quay the first floor is constructed to support a crane road. On the inner side the flat roofs of the warehouses project over 10 ft. to form shelter to a railway line.

In *Fig.* 1 we show a general view of the warehouses.

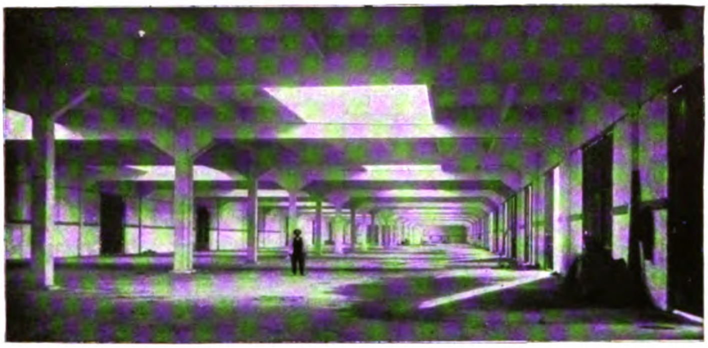


FIG. 2. Interior view.
REINFORCED CONCRETE WAREHOUSES AT MARSEILLES.

The first floor has been constructed for the unloading of grain. Special elevators convey the grain from the steamers on to the first floor, on which it is distributed. The grain may then be unloaded into wagons by means of holes in the floor, to which are fitted special tubes. When the goods arrive in bags they are taken up by electric cranes and conveyed to the ground floor by means of slipways. Large doors have been provided on the inside face of the buildings by which goods may be loaded into the trains running alongside the warehouses.

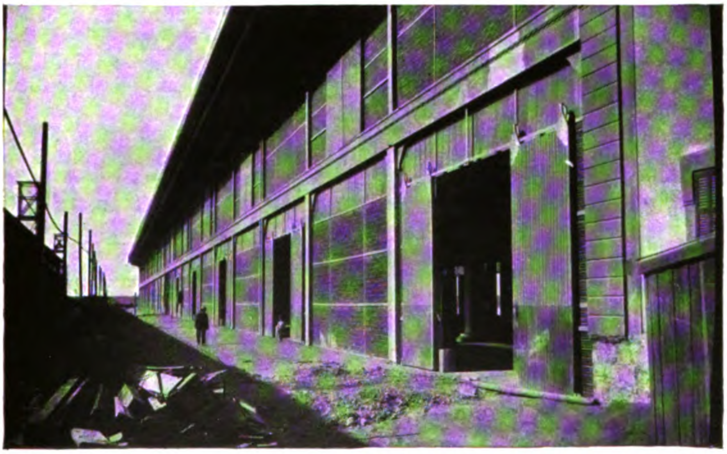


FIG. 3. Exterior view of one of the warehouses.
REINFORCED CONCRETE WAREHOUSE AT MARSEILLES.

With regard to the foundations, the pier is composed of wooden piles driven into the filling. The concrete foundation has been made on the top of the piles and the footings of the reinforced concrete pillars are built directly upon this ordinary concrete foundation.

The structure of the buildings is entirely made of reinforced concrete, with the exception of the small-end elevations, which are made in brickwork.

The longitudinal elevations are made of brick panels supported by reinforced concrete lintels and pillars.

In *Fig.* 2 details of the interior of the structure are shown.

On the ground floor the pillars are spaced about 23 ft. centre to centre transversely and 32 ft. 5 in. longitudinally.

The floor itself is composed of principal beams and secondary beams supporting a slab 6 in. thick, covered with 6 in. of asphalt.

The pillars on the first floor are spaced at the same distance centre to centre on a longitudinal direction, as on the ground floor, but there is only one row of pillars.

The principal beams supporting the roof are, therefore, over 46 ft. in span.

The roof, which supports twenty-two skylights, has been made watertight by means of four layers of specially prepared paper-sheeting covered with 4 in. of gravel.

All the beams of the floors and roof are, according to the Coignet system, known as "Armature of equal resistance."

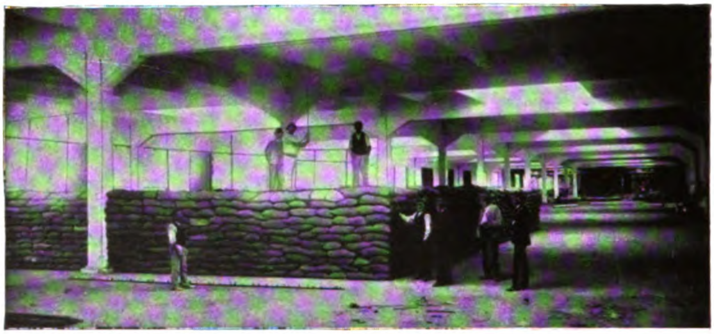


FIG. 4. Showing test on first floor.
REINFORCED CONCRETE WAREHOUSE AT MARSEILLES.

Owing to the considerable length of the building it has been found advisable to divide the floor into six portions of about 131 ft. each, entirely independent the one from the others.

As shown in *Fig.* 3, the spaces between the reinforced concrete lintels and pillars are filled in by hollow bricks, strengthened by vertical and horizontal rolled steel stanchions.

The access to the first floor is provided for by means of four staircases. Each building is fitted with sixty-four large rolling metal doors. Half of these are on the ground floor and the other half on the first floor.

The testing of the floors was carried out under the control of the Dock Engineer, and proved most satisfactory. *Fig.* 4 shows the test during progress.

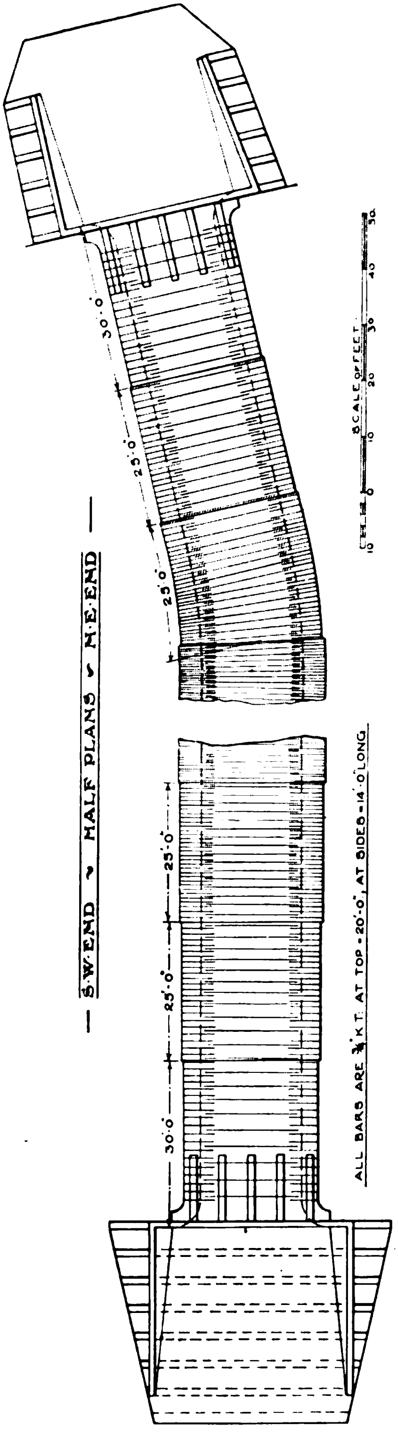
The contract undertaken by M. Edmond Coignet included the complete erection of the two buildings, with the exception of the foundations, and machinery and conveyors.

The works were begun on the 1st January, 1908, and the main structure of the first building was finished at the end of May, and the corresponding part of the second building on the 15th September—namely, eight and a half months after.

The remainder of the general contract, sucn as skylights, doors, renderings, brickwork, etc., was finished at the end of October, 1908, or ten months after the beginning of the works.

The work was executed in ten months, whereas it would have necessitated probably a maximum of fifteen months to construct these warehouses in steelwork.

The total amount of the contract, with the exception of the foundations, was 1,478,000 francs (£59,120), whereas the same work in steel would have cost at least 1,650,000 francs (£66,000), which is a good example of the economy of using concrete.


S·W·END · HALF PLANS · N·E·END
30'·0"
25'·0"
25'·0"
25'·0"
25'·0"
30'·0"
SCALE OF FEET
10 0 10 20 30 40 50
ALL BARS ARE ¾ K.T. AT TOP - 20'·0", AT SIDES - 14'·0" LONG

Details showing external reinforcement.

REINFORCED CONCRETE CULVERT AT KILTON.

REINFORCED CONCRETE CULVERT AT KILTON.

We illustrate in this article a reinforced concrete culvert, which has been built under the North-Eastern Railway line between Skinningrove and Kilton, to provide a waterway at the bottom of a valley, which is at present spanned by a viaduct.

The work was designed throughout by the Engineering Department of the Trussed Concrete Steel Company, Limited, of Caxton House, Westminster, S.W., under the supervision of Mr. W. J. Cudworth, late Chief Engineer of the North-Eastern Railway, and the requirement was that the culvert should be sufficiently strong to resist subsidence due to mining operations below, in addition to the weight of a high embankment.

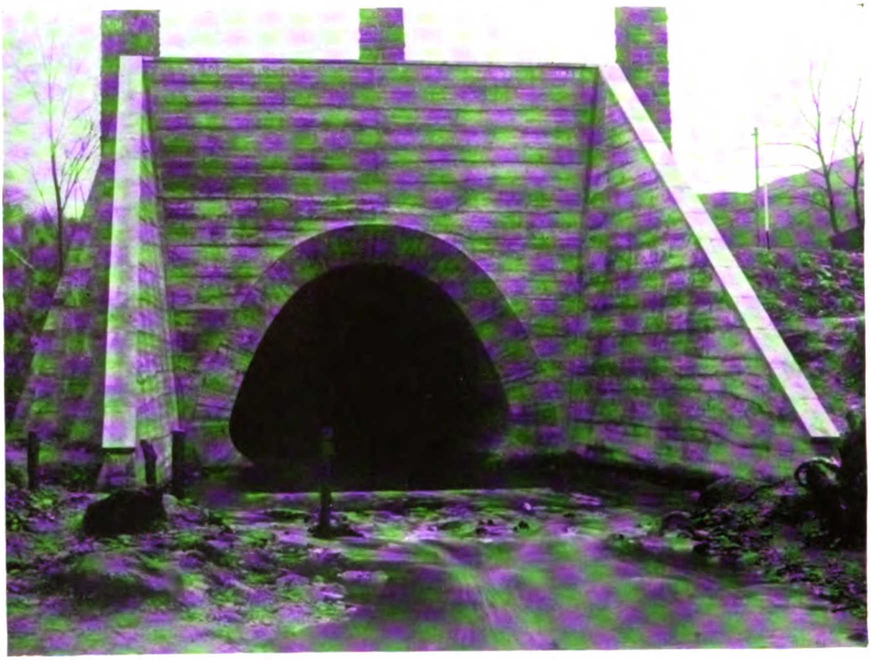
The piers of the viaduct, which rise about 150 ft. above the bottom of the valley, having shown signs of subsidence, the railway company decided to construct an embankment across the valley underneath the viaduct, which was consequently to be discarded. The embankment is to be carried up to the present level of the rails, and will probably be, when finished, the highest in England.

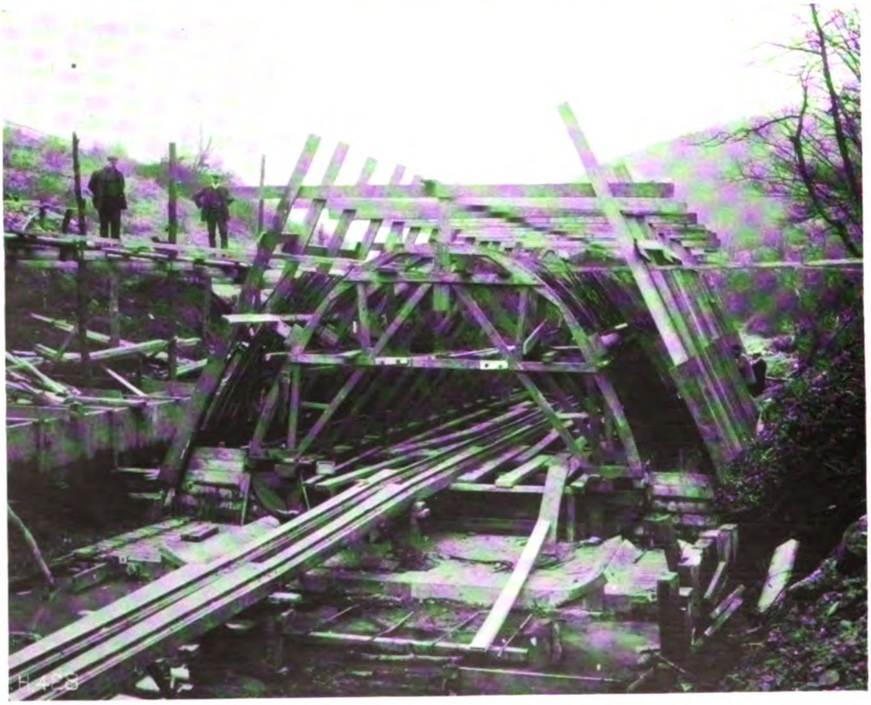
The culvert, as will be seen from the drawings, is of unusual size, the thickness of the reinforced concrete at the crown being 18 in. It is of large area, having to accommodate great volumes of flood water at various times of the year. Owing to the bad nature of the ground forming the sides of the valley and the extra pressure brought upon the culvert by carrying up an embankment of the height required, the inlet and the outlet had to be designed of unusual strength to prevent the sides being forced in by the earth pressure outside, and it was found necessary to put in reinforced concrete struts under the floor, both at the inlet and the outlet, so as to prevent the retaining walls from sliding towards the centre of the culvert. The total length of the culvert is 450 ft., and the reinforcement of the arched portion is entirely composed of Kahn trussed bars.

The embankment is now being filled up with shale taken out of the mining pits on each side of the valley.

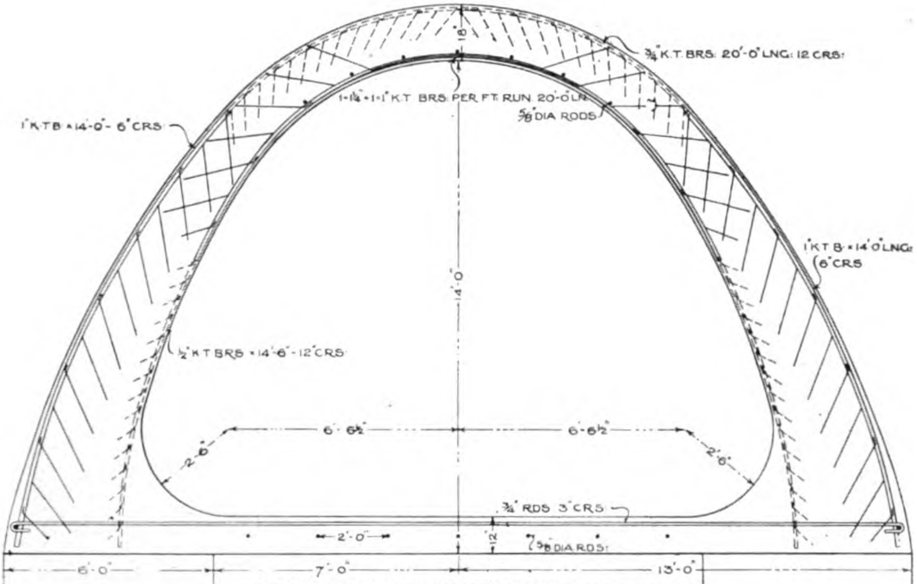
In designing the culvert the full pressure of the earth filling the embankment 150 ft. high was taken into consideration, and the conditions required by the railway company were that the calculations should be based on the assumption that only one side of the arch was loaded, this being

View of end of Culvert.

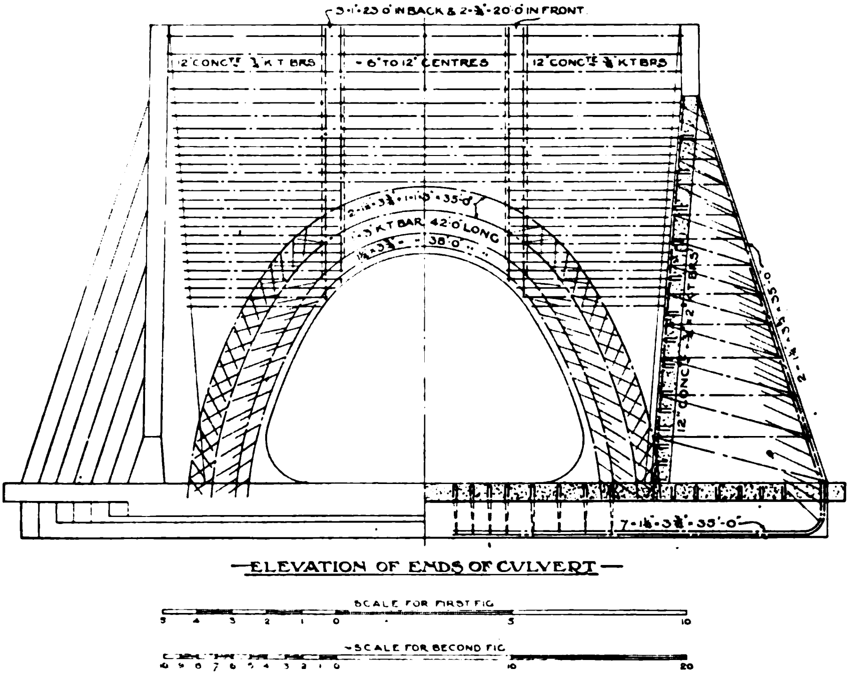




View of centering and forms in position.
Reinforced Concrete Culvert at Kilton.


¾" K.T. BRS. 20'-0" LNG. 12 CRS.
1-1¼"+1-1" K.T. BRS. PER FT. RUN. 20'-0" LN.
⅝" DIA RODS.
1" K.T.B. × 14'-0" - 6" CRS.
18"
14'-0"
1" K.T.B. × 14'-0" LNG. (6" CRS.
½" K.T. BRS. × 14'-6" - 12" CRS.
6'-6½"
6'-6½"
2'-6"
2'-6"
¾" RDS. 3" CRS.
2'-0"
12"
⅝" DIA RDS.
6'-0"
7'-0"
13'-0"

REINFORCEMENT TO CENTRE PORTION × 275 FT. LONG

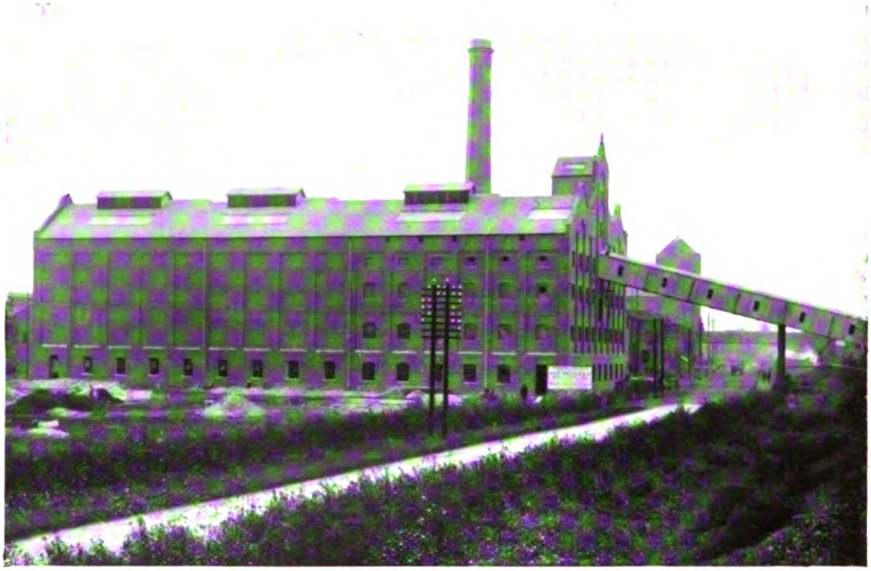


ELEVATION OF ENDS OF CULVERT

Detail section and elevation of Culvert.

REINFORCED CONCRETE CULVERT AT KILTON.

considered the most stringent condition that could be imposed. This was done because it was thought that such conditions would probably nearly represent what might happen in case the ground settled under one side of the culvert.



Reinforced Concrete Silos and Warehouses at Selby, Yorks.

Another View of Silos and Warehouses at Selby.

Upon completion, the culvert was tested with rails to the full working load of 5 tons per super foot, in the presence of the North-Eastern Railway Company's engineers, the rails being loaded on the crown of the arch only. The culvert was, therefore, not assisted by any side pressure which would have been exerted had the testing material been built right round the arch. A deflecting instrument was placed under the crown of the arch before the test began, and daily observations were made during a whole week. There was no deflection, although the test load was allowed to remain in position for several days.

REINFORCED CONCRETE SILOS AND WAREHOUSES AT SELBY, YORKS.

The silos and warehouses, also conveyor bridges illustrated on the opposite page, were constructed in reinforced concrete by Stuart's Granolithic Co., Ltd., of 4 Fenchurch Street, E.C., for the Olympia Oil and Coke Co., Ltd., at Selby, Yorks.

The overall dimensions of the silo are 111 ft. 7 in. by 93 ft. 7 in. and 35 ft. high.

There are 54 bins in all, each 12 ft. 15 in. centres, with a total capacity of 5,700 tons, all of which may be unequally distributed—*i.e.*, one bin may be full while the surrounding bins are empty.

On top of the bins are a series of gangways, the load for the floors of these gangways being 2 cwt. per ft. super.

The floors of the warehouses alongside the silos are all in reinforced concrete and are 5 in. thick, inclusive of granolithic finish, this thickness being required for the enormous traffic which circulates over them.

The weight to be carried by the floors of the warehouses is 4 cwt. per ft. super, safely distributed over and above the static weight of the structure.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

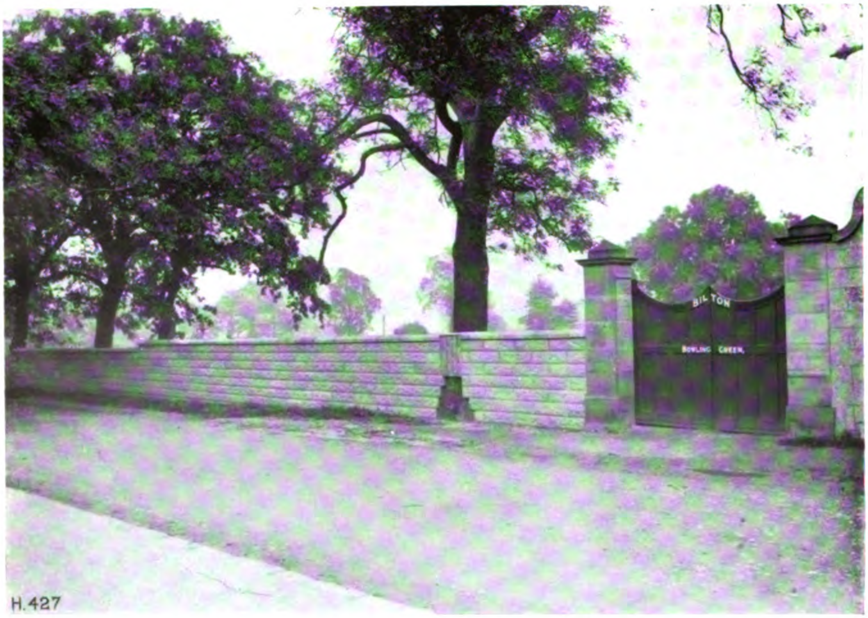
CONCRETE BLOCKS FOR BUILDING PURPOSES.

THE illustrations of the houses in this article are excellent examples of the use of concrete blocks for buildings. This method of construction is very useful where economy of time and labour is essential.

The design of the Bungalow at the Garden City Suburb, Bilton, is very attractive, and the boundary wall of the bowling green at Bilton, illustrated below, is also formed of concrete blocks, and presents a very pleasing appearance.

These concrete blocks have many advantages. They are easily laid, which saves a lot of expense in the erection of a building, and the inside face of walls built with blocks is so even that only one thin coat of plaster is required, which is also economical. The blocks are lasting, fire-resisting, and cheap.

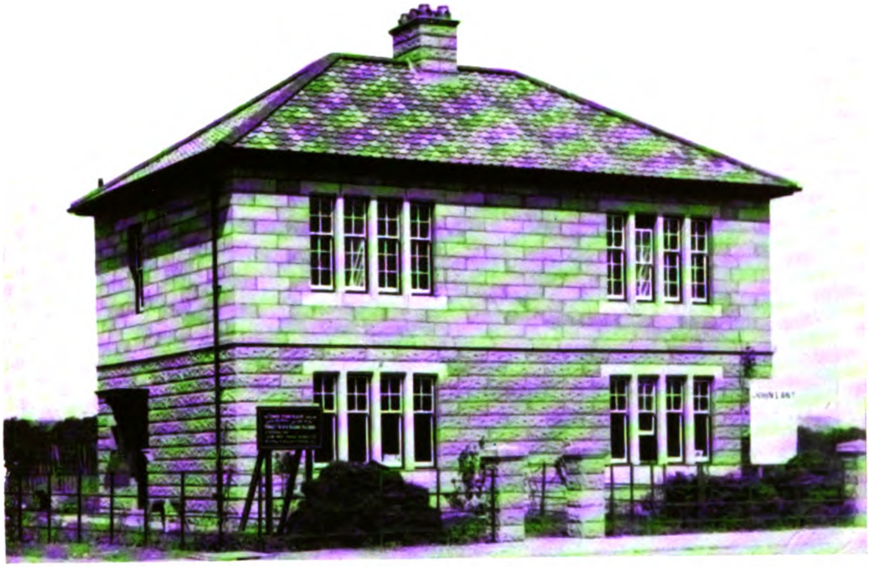
The blocks used in these buildings were made by Chas. A. Nettleton, contractor, of Harrogate, and the Newcastle Grindstone & Pulpstone Co., Ltd., of Newcastle-on-Tyne, on the "Winget" Concrete block making machine, the proprietors of which are the U. K. Winget Concrete Machine Co., Ltd., of Newcastle-on-Tyne. Their machine moulds hollow or solid building blocks at the rate of 300 32-in. by 9-in. by 9-in. per day.

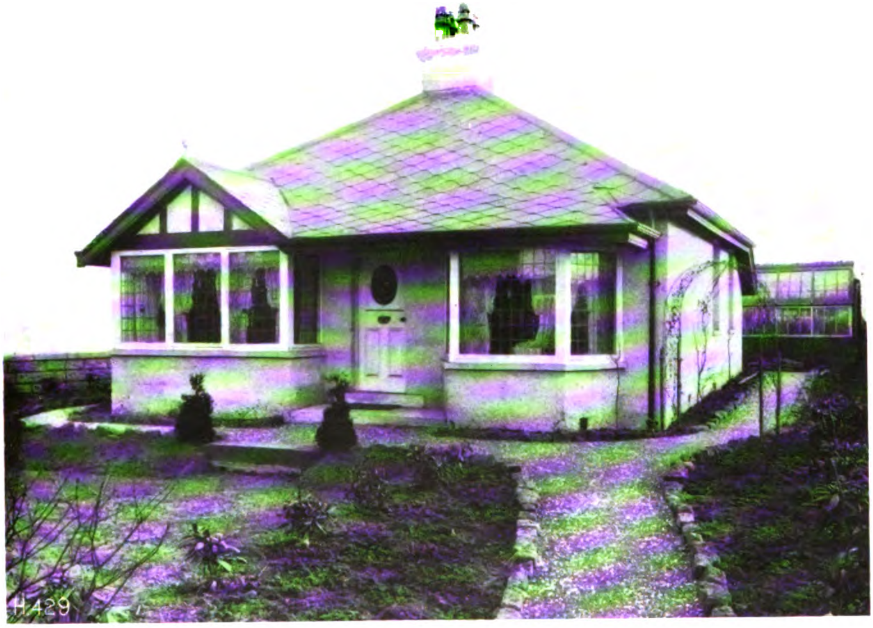


BOUNDARY WALL, BILTON BOWLING GREEN.

Built of "Winget" Concrete Blocks.

Cottage at Walker Gate, Newcastle-on-Tyne.





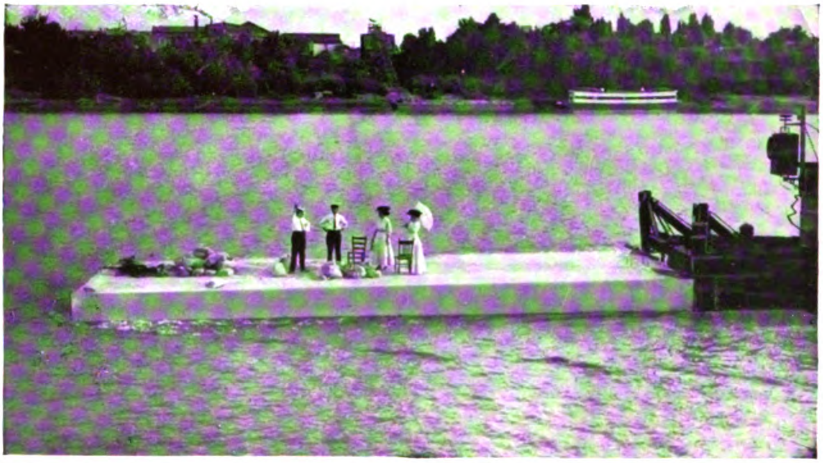
Bungalow at Bilton, Harrogate.
Built of "Winget" Concrete Blocks.

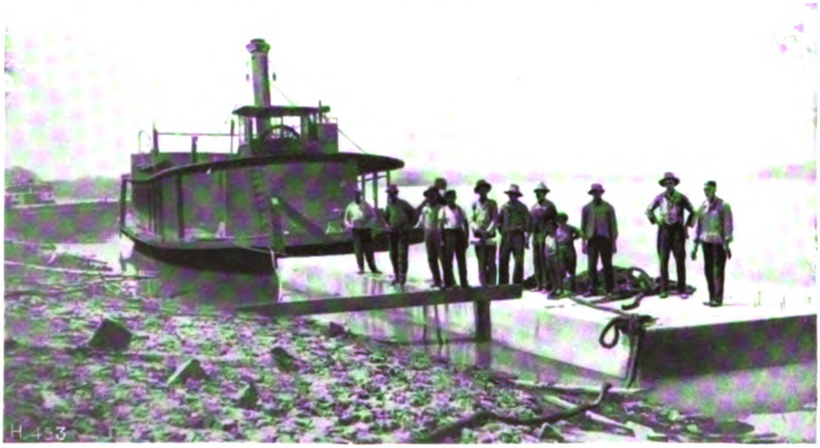
FLOATING REINFORCED CONCRETE DOCK.

The illustrations we show are of a floating reinforced concrete dock erected at Owensboro', Kentucky, by Messrs. G. A. Whitehead & Co., contractors, who use it daily as an unloading dock for sand and gravel, and find it far superior to any wooden structure, requiring no attention whatever.

The dock is 16 ft. wide by 50 ft. long and 3 ft. deep. It is constructed with 30 water- and air-tight compartments, which make it impossible to sink it. This dock has recently been frozen in the ice without the slighest damage, as the river was full of ice for several weeks, and all wooden boats had to seek ice harbours.

The dock was recently tested very thoroughly, and with most satisfactory results.



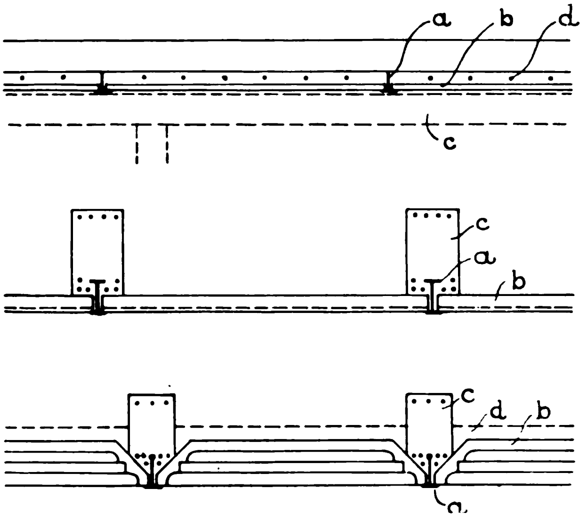


Floating Dock at Owensboro', of Reinforced Concrete.

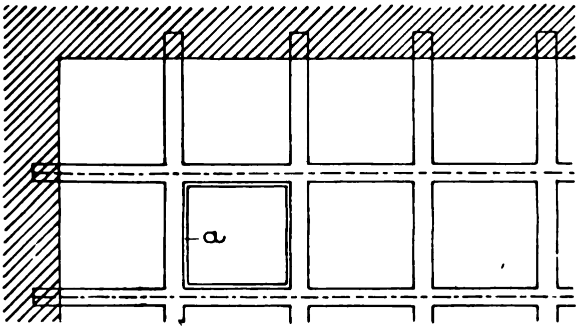
A METHOD OF CONSTRUCTING REINFORCED CONCRETE FLOORS, ETC., WITHOUT SHUTTERING.

The method of constructing reinforced concrete floors, roofs, walls, columns, etc., without the use of shuttering—which we are describing and of which we show illustrations—ensures a considerable saving both in the capital locked up in the form of boarding, and the labour in erecting and removing the shuttering.

Light steel **T**-joists or other sections are placed at suitable distances apart, and temporarily supported by a prop in the middle. Concrete slabs, previously prepared at the site or elsewhere, are then laid to form the lower surface. Concrete beams or a concrete floor are constructed in place, as shown, the boarding required for the beams in the second figure being removed as soon as the concrete has set, in 1—1½ days, and again used. The upper parts of the steel joists serve as part of the reinforcement, and other reinforcing rods are introduced where necessary. Insulating material, sand, etc., may be filled in above the slabs, and a wooden floor laid above.



ALTERNATIVE METHODS OF CONSTRUCTION.



A METHOD OF CONSTRUCTING REINFORCED CONCRETE FLOORS, ETC., WITHOUT SHUTTERING.

The lower figure on this page represents a floor carried on all sides by the walls. Square wooden frames, *a*, are the only centering required. A ceiling divided into compartments may be constructed as shown in detail section, the slabs *b* being previously prepared and laid on the flanges of the joists, *a*. Beams *c* are constructed, and a filling *d* is then added.

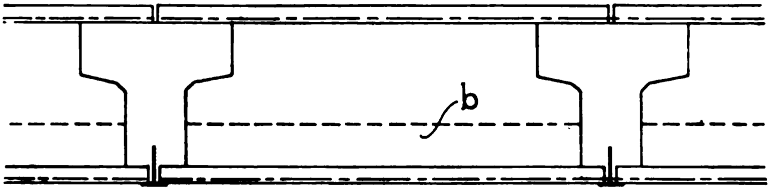
Arched roofs may be constructed similarly by bending the **T**-joists to the required curve. For columns, the concrete slabs form the outer surface, the corners being composed of angle-iron.

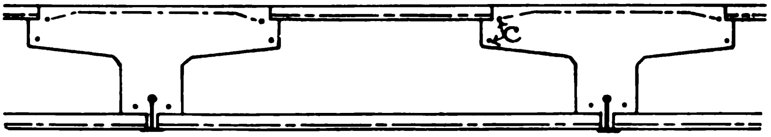
The system is recommended by its simplicity, and by its low capital cost, especially where wood is scarce.

Particulars as to this method of construction may be had from Mr. J. Virck, architect, of Malchow, Mecklenburg.

T-BEAMS AND T-BEAM FLOORS.

Mr. Virck has also sent us particulars of a patent which he has taken out for another method of constructing floors. In this system floors and ceilings are carried by **T**-beams, thus economising concrete. The flooring may then be of less thickness on account of the reduced distance between the beams. If the **T**-beams are still further broadened, as in the lower figure in our illustration, the intervals may be filled by thin concrete slabs or by brick arches. The **T**-beams are then made of correspondingly diminished height.





The hollows thus left in the floor may then remain open at the top during construction, and serve conveniently for the reception of pipes, for holding insulating material (*b*), or as ventilating passages for the lower rooms. In this way a cheap sound- and heat-proof floor is obtained. The lower concrete slabs should be about 3 cm. ($1\frac{1}{8}$ in.) thick, and the upper 3—4 cm. ($1\frac{1}{8}$—$1\frac{1}{2}$ in.).

The **T**-beams are built into the supporting walls at the ends, and if of long span they are supported by a column in the middle. In order to guard against lateral thrust or shock during building, the edges of the plate are reinforced with rods (*c*).

REINFORCED CONCRETE CHIMNEYS IN MEXICO.

While not a new departure in the field of reinforced concrete, two chimney stacks, designed by H. Eckardt, engineer, and recently constructed by Carl Leonhardt, contractor, of Los Angeles, California, in connection with pumping stations for the Cananea, Rio Yaqui and Pacific railroad in Sonora, Mexico, present some features of interest and at the same time evidence increased faith and favour for this class of work.

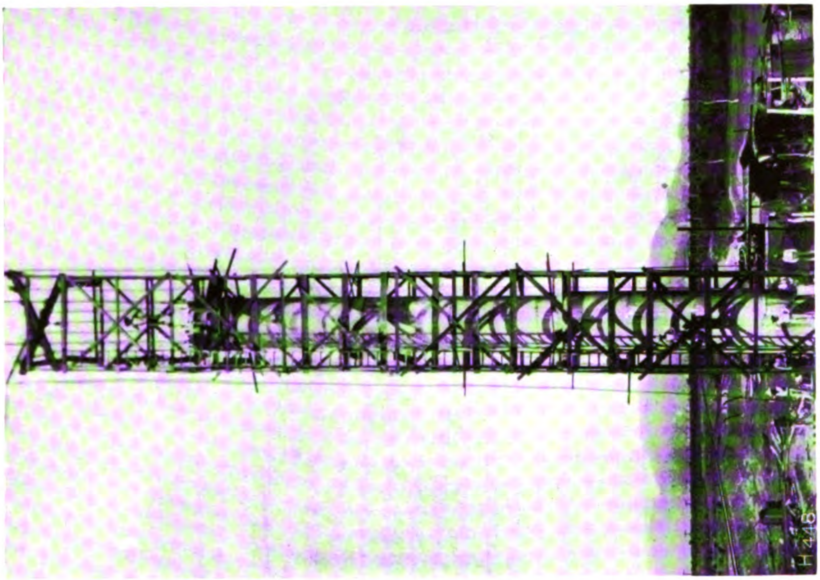
The two stacks are located at Kilo 4, South of Guaymas, and at Empalme, the former having a height of 105 ft. and inside diameter of 4 ft., and the latter being 150 ft. in height and with an inside diameter of 6 ft. 6 in.

The foundation for the stack at Kilo 4 is circular in form, having a diameter of 20 ft.; is cast on piles and reinforced with 1-in. steel rods in web system with 9-in. centres.

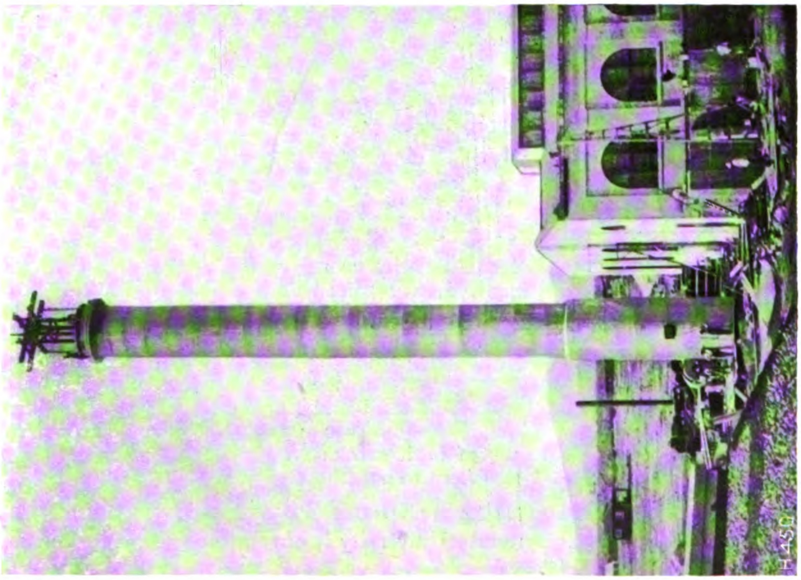
Upon this circular base is mounted, in the shape of a frustum of a cone, another mass of concrete with a 20-ft. base, an 8-ft. 10-in. top, and 3 ft. in height. The completement of the foundation is reached with a concrete cylinder, having an outside diameter of 8 ft. 10 in. None of this is visible in the finished stacks, the three sections forming a monolithic mass.

The superstructure of the stack proper presents the appearance of two superimposed cylinders, the lower having an outside diameter of 7 ft. 10 in., the upper 6 ft. 10 in. There are three stages of decrease in the thickness of the inner and outer walls, four in the vertical reinforcement, and two in the horizontal. The general section presents an outside wall or shell, an air chamber in five equal compartments increasing in width in ratio to the height and decrease of outer and inner walls, and an inner or flue wall.

The lower section or cylinder is 30 ft. in height, has an outside wall of 12 in., 6-in. air chambers, and a 5-in. flue wall. The second section is 40 ft. in height, has an outside wall of 6 in., a 6-in. air chamber, and a 5-in. flue wall. The last section, presenting to the outward view the same dimensions as the second section, has outside wall of 4½ in., 9-in. air chambers, and a 3½-in. flue wall.



Showing construction of chimney.



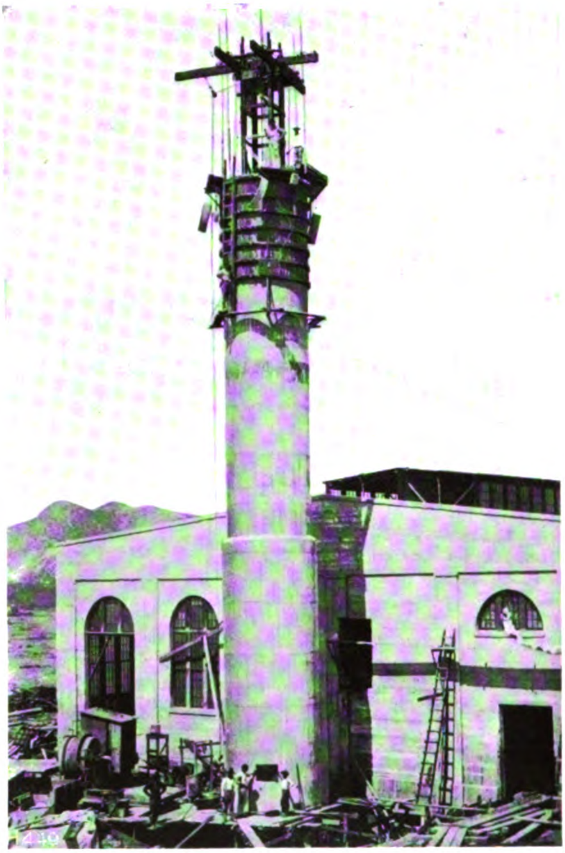
View of chimney nearing completion.

Reinforced Concrete Chimney at Empalme, Mexico.

The reinforcement consists entirely of twisted steel rods, the thickness varying in proportion to the height. The lower 30 ft. are reinforced vertically in the outside wall with thirty-six equally spaced 1-in. rods, the flue or inner wall with eighteen ¼-in. rods. Horizontally, the same section has ⅜-in. rings, spaced 24 in. centre to centre; in the outside wall $\frac{5}{16}$-in. rings, spaced 18 in. in the flue wall. The remaining 75 ft. of stack have a uniform horizontal reinforcement of ¼-in. rings, spaced 24 in. in the outside wall, and ¼-in. wall rings, spaced 18 in. in the flue wall.

The vertical reinforcement for the next 31 ft. consists of eighteen 1-in. rods in the outside wall and nine ¼-in. rods in the flue wall. Following this are 28 ft. with eighteen ⅝-in. rods in the outside wall and nine ¼-in. rods in the flue wall. The last section of 16 ft. has eighteen ⅜-in. rods in the outside wall and nine ¼-in. rods in the flue wall.

The forms used were built in Los Angeles and shipped to Empalme; they were constructed in 12-ft. lengths for the outside and 6-ft. lengths for the inside; this stack had the scaffolding that carried the working-platform, also the screws for lifting the forms. The air-chambers were lifted by hand, being constructed in such a manner that they collapsed when one key was removed, and could easily be raised by one man. The concrete, of which 250 cubic yards were required, was raised by gasoline engine and from the inside of the smoke-stack.


REINFORCED CONCRETE CHIMNEY AT KILO 4, MEXICO.

The smoke-stack at Kilo 4, South of Guaymas, also for the same railroad, had a height of 105 ft. by 4 ft. inside diameter, and was constructed in the same manner as the stack at Empalme, with the exception that it was scaffolded from the outside.

The reinforcements totalled 5 tons of steel and the work required 227 barrels of cement, 70 cubic yards of sand, and 105 tons of rock; 135 cubic yards of concrete were required for the work. The heads of both stacks were built of concrete, the forms for the same being built of ⅜-in. stuff bent to suit the design.

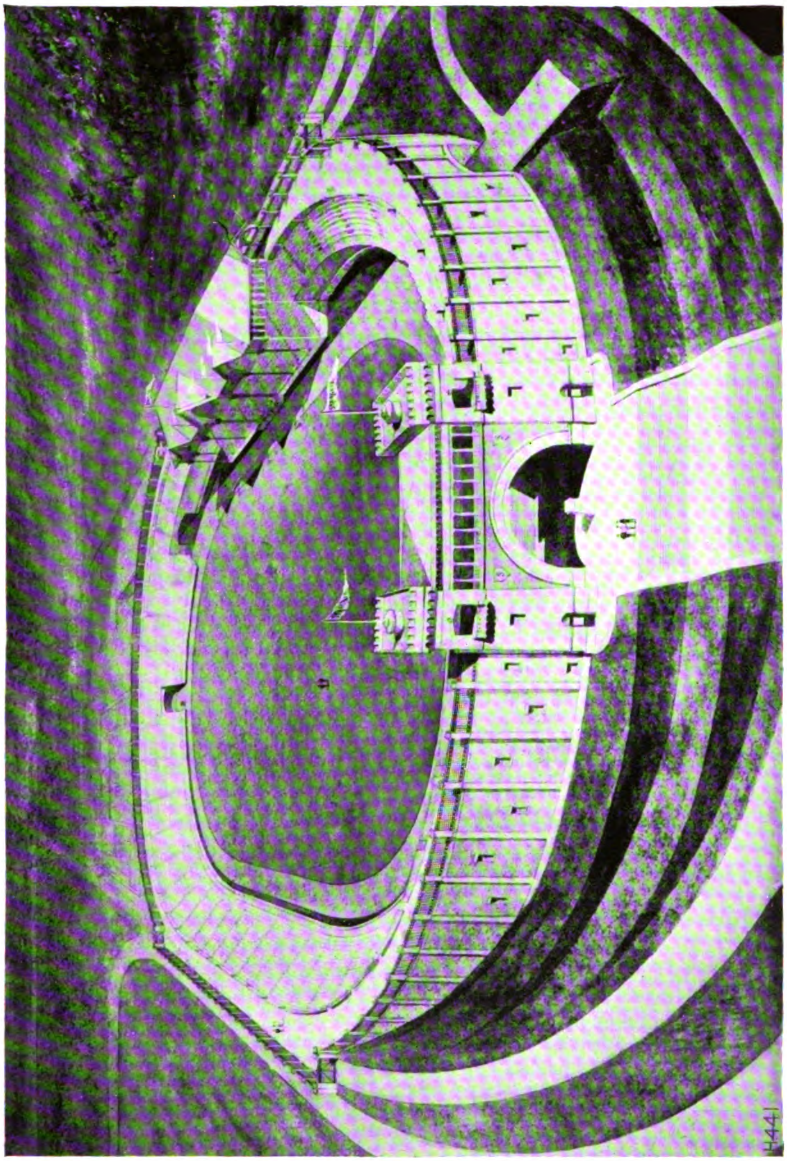
REINFORCED CONCRETE STADIUM AT SYRACUSE, U.S.A.

THE Stadium recently built at Syracuse University is of reinforced concrete construction throughout.

The general dimensions of the stadium are as follows:—Length on long axis, 670 ft.; on short axis, 475 ft. Area covered 6⅓ acres. The normal seating capacity of the stadium is 20,000, with a possible seating capacity of 40,000.

At the top of the seats there is a concrete wall 3 ft. 6 in. high. Outside this wall there is a promenade of concrete, 20 ft. wide, covered with asphalte. It is surrounded by a concrete curb 2 ft. wide.

The whole superstructure is supported on concrete piers, the footings for which are carried down to solid soil. Where no fill existed the footings extend 4 ft. 6 in. below the ground. The main girders are 2 ft. deep and 1 ft. wide.



Reinforced Concrete Stadium at Syracuse, U.S.A.

The approach to the main entrance consists of concrete stairs and platforms, and two stairways of reinforced concrete also lead from the ground floor to the offices which are located in the towers, which are about 16 ft. above the field.

On the outer edge of the promenade surrounding the structure are placed ornamental concrete posts 2 ft. sq. and 9 ft. high. On about every third post an arc lamp is located with electric conduits encased in the concrete post.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

CONCRETE INSTITUTE ANNUAL GENERAL BUSINESS MEETING.

THE Concrete Institute have sent us the following account of their first annual meeting, together with a copy of the Council's report :—

The first Annual General Meeting of the Concrete Institute was held at the Royal United Service Institution, Whitehall, on February 17th, the Right Hon. the Earl of Plymouth, C.B. (late First Commissioner of Works), President, in the chair, supported by Sir Henry Tanner, I.S.O., Mr. E. P. Wells, J.P., hon. treasurer, Mr. W. Dunn, F.R.I.B.A., and other members of the Council.

Letters of regret having been read from Sir William Preece, K.C.B., Vice-President, Mr. Edwin O. Sachs, F.R.S.Ed., and others, the result of the ballot for six vacancies on the Council was announced, the members elected being as follows: Messrs. C. H. Colson, M.Inst.C.E.; William Dunn, F.R.I.B.A.; Professor Henry Adams, M.Inst.C.E.; Messrs. William G. Kirkaldy, Assoc.M.Inst.C.E.; J. S. E. de Vesian, M.Inst.C.E., and E. Fiander Etchells, F.Phys.Soc.

The Hon. Treasurer thereupon read the annual report and accounts, the adoption of which was moved by the Earl of Plymouth, who dwelt on the satisfactory progress which the Institute had made. This was seconded by Sir Henry Tanner, who referred to the work of Mr. Edwin O. Sachs in the foundation of the Institute, and was spoken to by Mr. F. E. Wentworth-Shields, M.Inst.C.E., and Mr. E. Fiander Etchells, F.Phys.Soc., who both dealt at some length with the work of the Science Standing Committee.

After the discussion of various matter of detail, Mr. William Dunn proposed, and Sir Henry Tanner seconded, a vote of thanks to the Earl of Plymouth for presiding on this occasion and for his services to the Institute.

REPORT OF THE COUNCIL.

The Concrete Institute, which originally started with one hundred founders, had on December 31, 1909, 850 Members and 17 Special Subscribers. The membership is still increasing.

The principal work of the Council of the Institute since its formation has, to a great extent, been constructive, including the incorporation of the Institute.

Special Committees have been formed from time to time to attend to various technical matters, and of those that are now in full working order the Science and the Parliamentary Standing Committees may be specially mentioned as having materially contributed to the work of the Institute.

The General Meetings, which have been held for the presentation and discussion of papers, have been most successful, the attendances being satisfactory and the discussions of considerable interest.

Transactions of the Institute, containing papers with full reports of the discussions and other information concerning the work of the Institute, have been published from time to time.

During the summer months arrangements were made by which members of the Institute had an opportunity of visiting works and other places of interest. These visits, which were attended by a large number of the members, were of an instructive character.

The thanks of the Institute are due to the authors of the papers and to those who acted as hosts on the occasions of the visits referred to.

Besides the organisation of these meetings and visits, the Institute has done much useful work in other directions. There are two matters which call for special attention—namely, the part it has played in the Amendment of the London Building Act, and its effort to introduce a Standard Notation for Reinforced Concrete.

With reference to the first matter, the Council of the Institute felt that, although a young Society, it ought to have a voice in the Amendment of the London Building Act, so far as that Act affected reinforced concrete structures. Accordingly, the House of Commons was petitioned by the Institute and various conferences were attended by its delegates. It is satisfactory to report that the new Act recognises the representative character of this Institute, and that it is now one of the various bodies which have to be consulted in the matter of regulations for reinforced concrete construction in the County of London.

Again, a most useful work may be said to have been initiated by the suggested Standard System of Algebraical Symbols to be used in calculations for reinforced concrete. The matter has aroused considerable interest both in this country and abroad, and it is hoped that the list of symbols prepared by the Science Standing Committee will be soon adopted by the English-speaking nations.

With regard to the finances of the Institute, it is satisfactory to note that in spite of heavy expenses necessarily incurred by the Incorporation of the Institute and by Parliamentary and other matters, these expenses have all been met, and there is a small balance in hand.

The Council gladly welcome suggestions which are made from time to time with a view to increasing the influence and usefulness of the Institute. Some of the suggestions are here set out in order that members may have an opportunity of considering and discussing them.

1. That a series of meetings should take place once a year on two or three consecutive days. Papers could then be read and discussed, and the Annual General Meeting could be held at the same time. It is thought that this arrangement would make it worth while for members living at a distance to come to London for the purpose of attending.
2. That branches of the Institute be formed in provincial towns for the benefit of those members who reside in them.
3. That a Graduate Section be formed of Juniors who are anxious to study technical matters in concrete and reinforced concrete.

In accordance with the Rules of the Institute six vacancies have occurred on the Council, and these have been filled by ballot.

The Council has to report with sincere regret that Mr. A. E. Collins has resigned the position of Honorary Secretary. Mr. Collins finds that he is unable to attend the meetings of the Institute owing to his time being fully occupied by an important public appointment. He will continue, however, to remain a member of the Council, and to give the Institute his co-operation and assistance.

Reinforced Concrete Dam at Keokuk.—H.M. Consul at St. Louis has forwarded an extract from a local paper, from which it appears that it is intended at an early date to begin work on the construction of a reinforced concrete dam 5,800 ft. long, 37 ft. high, and 37 ft. wide at the bottom, across the Mississippi River at Keokuk, with a view to the generation of electric power for supplying the City of St. Louis. The cost of the work is estimated at 12,000,000 dollars (about £2,500,000). Further details, given in the extract referred to above, may be seen by British firms interested on application at the Commercial Intelligence Branch of the Board of Trade, 73 Basinghall Street, London, E.C.

Tenders for a Reinforced Concrete Bridge. — The Corporation of Merthyr Tydfil invite tenders for the construction of a reinforced concrete public road bridge, 76 ft. span, over the River Taff at Merthyr Vale, and for other work in connection therewith. A copy of the specification, together with a general drawing giving plan, elevation, section, and cross-sections of the suggested bridge may be obtained from T. Fletcher Harvey, Borough Engineer, Town Hall, Merthyr Tydfil, upon payment of £2 2s. (which will be returned on receipt of a *boná-fide* tender, accompanied bv detailed drawings of the work, and description and weight of steel reinforcement). Sealed tenders, endorsed "Aberfan Bridge," must reach Mr. T. Aneuryn Rees, Town Clerk, Town Hall, Merthyr Tydfil, not later than noon on Saturday, March 12th, 1910. The Corporation do not bind themselves to accept the lowest or any tender.

Reinforced Concrete Culvert at Macclesfield.—The Highway Committee of the Corporation recommend approval of the scheme of the Borough Surveyor to divert a culvert in a straight line from Commercial Road to the River Bollin in a 21-in. reinforced concrete tube, at an estimated cost of £64 12s. 6d.

Reinforced Concrete Gas Conduit.—A pressure main of reinforced concrete, 36 in. diameter inside and 334 ft. long, is in use at Salt Lake City. The maximum static head which it withstands is about 20 ft. of water. The thickness at the top of the section is 6 in., and at the sides 7 in. The bottom is constructed in the form of a section of an octagon, with a minimum thickness of 6 in., and the reinforcement consists of ⅜-in. square twisted steel bars, spaced 8 in. on the centres. This conduit has been in use seven years, and, according to the City Engineer, is in first-class condition.

Proposed Cliff Improvement at Clacton.—At a recent meeting of the Clacton Urban Council the Sea Defence Committee reported that the recent heavy gales had caused damage to the wooden sea wall and Promenade, and they had directed that a concrete buttress be constructed at the point where the piles had been thrust forward, and that a concrete apron be constructed for a distance of 20 ft. on each side.

Bridge over the Tiber.—The municipality of Rome, after considering competitive tenders from several firms which make a speciality of construction in reinforced concrete, has just entrusted to the Società Porcheddu Ing. Giov. Antonio, of Turin, the work of building a new bridge over the Tiber in the neighbourhood of the Piazza d'Armi fuori Porta del Popolo.

The bridge will consist of a single arch with a span of 100 metres, with a flat rise of 1 in 10, and the roadway will be 20 metres broad. The cost is estimated at £50,000. The work is to be finished in the exceptionally short period of 15 months, so that the bridge may be ready in the early part of 1911, at the inauguration of the International Exhibition which is to be held at Rome in that year.

The structure, on which work has already started, will be carried out in reinforced concrete, and it is proposed to face the bridge with artificial stone resembling limestone. The roadway will be paved with cement and asphalte, on the special system of the Società Porcheddu.

Concrete Poles.—Concrete poles hexagonal in shape and hollow through the centre are used by the Oklahoma Gas and Electric Company. A 35-ft. pole measures 7 in. across at the top and 16 in. across at the butt. They are moulded in forms made up of 5-ft. sections, so that it is possible to cast a pole of practically any length. Steel rods are placed symmetrically about the central axis and at the top and bottom project through holes in steel plates. The rods are bent over at each end and securely fastened. The core, which is wrapped with one thickness of building paper, is suspended within the form by wires at intervals along its length. The concrete used consists of a mixture of one part cement, two parts sand, and three parts chats or zinc tailings.

Cement Tanks in France.—The American Consul at Bordeaux in a recent report drew attention to the French utilisation of the improved cement tanks lined with glass. Several years ago cement tanks began to take the place of wooden tanks in a number of the larger wine storage houses. One of the reasons for this substitution appears to have been the cheaper cost of material for cement tanks, as the price for timber had been gradually rising, and even at the higher prices was scarce and difficult to secure.

The effort to place acid-proof linings or coating on the walls of cement tanks seems to have proved of slight value in the matter of ameliorating the conditions of absorption. The idea of coating the walls with squares of glass, tightly joined with cement, is said to have solved the difficulty, as a tartar forms on the thin surface of cement and resists all acid attacks.

These tanks are particularly useful as storage receptacles for wines, alcohols, brandies, liqueurs, ciders, oils, gasoline, kerosene, turpentine, etc. It is said that tanks so constructed are neither affected by humidity nor by infiltrations, that they resist fire and inundation, and have a further advantage in that they are not liable to be struck by lightning as are tanks of metallic material. Variations of temperature effect a minimum loss by evaporation, the degree being reported at less than 1 per cent. At equivalent temperature wooden tanks lose between 6 and 7 per cent.

Reinforced Concrete Conduit in Mexico City.—It was recently reported that contracts were about to be made for the construction of four large reinforced concrete conduits in Mexico City, to extend to all parts of the city in which water is supplied by the Municipal Government. The conduits will be between 2 and 3 metres in diameter, and will, together, have a length of many miles. It is understood that the work will not be completed for three years. In addition to this work, new and heavy water pipes are to be installed in all parts of the city.

Reinforced Concrete Poles for Electrical Work.—There are, as is well known, a number of types of reinforced concrete poles now in use, but, according to *Le Génie Civil,* the Società Bresciana Cementi e Costruzione de Brescia have recently designed a new type which is being used on the tramway between Mestre and Trevisa. It is lozenge-shaped in section, the curves of the lozenge being concave. The core consists of eight iron rods at the base and four at the top of the pole. These poles carry a 10 mm. trolley wire and three 4 mm. wires; the span being 40 metres. This gives rise to the following stresses, the wires being supposed subjected to a wind pressure of 70 kg. per square metre operating on a cylindrical surface 6·4 metres above the section considered: Moment due to the weight of trolley wire 61·6 kg.; moment due to the wind pressure on the wires 394 kg.; moment due to wind pressure on the poles 344·4 kg.; adding 25 per cent. (200 kg.) for curves, etc., making a total pressure of 1,000 k.g. at the base—*i.e.,* 161·3 kg. applied at a point 6·2 metres above ground.

Concrete Pavements.—Concrete pavements have been laid upon a number of streets and bridges in Memphis, Tenn., according to the *Municipal Journal and Engineer.* In one place 500 ft. of street were paved with 1 : 2 : 4 concrete, 6 in. thick, consisting of Portland cement, sand and equal parts of crushed limestone and crushed granite; after seven years' use the pavement is said to be in excellent condition except for a width of 4 in. along the rails of a street car line. Another section was laid in 1903 upon a reinforced concrete bridge and the surface was finished with granolithic top, 1½ in. thick; up to the present time it is said that no repairs have been necessary. Three other bridges and a number of streets have also been paved with concrete within the last two years and have shown no appreciable wear. An experimental strip, 4,300 ft. long, was put down between the rails of a street car track and for 2 ft. beyond the outside rails. It consisted of a concrete foundation on which was placed a 3-in. concrete wearing surface. This construction, it is stated, has not been entirely satisfactory, and all concrete is now made monolithic.

Some experiences with Cement-lined Pipe.—From a recent paper by Leonard Metcalf, consulting engineer, Boston, the following interesting experiments with cement-lined pipe are taken :

"Brockton, Mass., has a 20-in. and 24-in. pipe, about 3 miles long, one-half of it running through a country district, the remainder through one of the outlying streets of the city. The latter half of the main has numerous connections. The original pipe shell was dipped in hot asphaltum and rolled in cement and sand before being placed. The lower end of the main is under about 50 lbs. pressure. The Superintendent states that there has been no trouble to speak of with this main during the twenty-eight years of its existence.

"Concord, Mass., has two 10-in. pipes, approximately 2½ miles each in length, the first in the year 1874 and the second in the year 1883. Both pipes are still in active service and have given comparatively little trouble from leakage. The maximum static pressure is approximately 40 lbs."

Proportioning Crushed Stone for Concrete.—According to Mr. Alfred Moyer, Assoc.Am.Soc.C.E., a saving in cement and sand may be effected and a much denser concrete obtained if two or three sizes of crushed stone are used, properly proportioned and mixed together. A simple method is as follows :

Supposing you have two sizes of stone, one passing a 1½-in. ring, the other passing a ¾-in. mesh. Screen the ¾-in. stone, taking out all that will pass through a ½-in. mesh, figuring that which screened out as sand. Make a receptacle which will hold approximately 4 cu. ft. (a piece of 15-in. sewer pipe will do). Measure 2 cu. ft. of the smaller

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stone and 2 cu. ft. of the larger stone, mix them well together with a shovel and place in the receptacle, mark the receptacle on the side the height to which the stone rises. Empty the receptacle and again measure out 2½ cu. ft. of the larger stone and 1½ cu. ft. of the smaller stone. Mix together as before, place in the receptacle and note on the side the height to which the stone rises. Experiment in this manner varying the proportion of the larger and smaller stones, always adhering to the total quantity of 4 cu. ft. The mixture which gives the least volume in the receptacle will make the densest concrete, and require the least amount of sand and cement. "Maximum density is maximum strength."

Attractive Surface Finish for Concrete.—An American paper gives the following method of providing an attractive surface finish for concrete:

Erect forms of rough boards by the usual methods, in courses of 3 ft. or less. Plaster inside of forms with wet clay, work to a plastic consistency which will adhere to the forms. Corners may be rounded by this method, and by indentations bead work and other designs can be accomplished.

While the clay is wet, apply evenly loose buff, red or other coloured sand, after which, pour in the concrete by the same method as applied to ordinary wet concrete construction; remove forms in usual time and after clay is dry, wash off the clay with water, and if necessary scrub with a brush. The sand will thus adhere to the concrete, giving a surface of pleasing colour and texture.

TRADE ANNOUNCEMENTS, CATALOGUES, ETC.

The Chain Concrete Syndicate, of Leeds and Castleford, have issued a neat booklet, showing photographs and drawings of some important works in reinforced concrete recently undertaken by them, and incorporating some articles relating thereto which have appeared in the technical Press. A distinctive feature of this firm's system consists of their adaptation of a patent clip, to provide against the possibility of the steelwork getting out of place during the process of concreting. These clips are made from flat bar steel ¼ in. thick, and from ½ in. to 1½ in. broad, according to the position which they occupy, and are cut by special machinery to the exact patterns required.

The Expanded Metal Co., Ltd., York Mansion, London, S.W., have issued a carefully arranged pamphlet dealing with "Expanded Metal Lathings for Plaster Work," which will, we have no doubt, be found both useful and interesting. They remind us that their expanded metal has been in successful use all the world over for the past 20 years. It is made from sheets of rolled metal of various thicknesses, cut and expanded by machinery into meshes of different shapes, each of which is made in several strengths or weights. The ¼-in., ⅜-in. and 7/16-in. mesh lathings, which are made from sheets of rolled steel, are well adapted to form a key for plaster in ceilings, steelwork encasing, partitions, exterior walls, etc. The special concrete meshes made from sheets of rolled steel are specially suitable as reinforcement for concrete in foundations, walls, floors, roofs, arches, bridges, reservoirs, dams, sewers, conduits, etc. The three types of expanded metal lathing—*i.e.*, the diamond mesh, cup mesh, and the square mesh, are illustrated and described, and general instructions as to spacing, methods of fixing, etc., are also given. Other matters dealt with are suspended ceilings on expanded metal lathing (profusely illustrated), steelwork encasing, thin walls and partitions, stairs and stepping, and light framed buildings.

Particularly interesting are the descriptions of cottages built at the Garden City, Letchworth, of which illustrations and sectional drawings are given. These cottages are built on a raft of concrete, with hollow walls of wood studs, expanded metal lathing and cement plaster. The illustrations show the framework in course of construction as well as the completed building.

Richard Johnson, Clapham & Morris, Ltd., of Lever Street, Manchester, have sent us a comprehensive and useful catalogue, excellently produced and illustrated, descriptive of their reinforced brickwork and the clothing of steel-framed and reinforced concrete buildings. In this system the reinforcement consists of a wire mesh, 2 in. and 2½ in. wide, with respectively three and four straight tensional wires running its entire length. When embedded in the mortar joints of the brickwork, this mesh forms a continuous bond, and the mortar, instead of being a filling only, becomes the strength of the brick wall. Plans of cottages of reinforced brickwork to cost £130 each, and descriptions of fireproof partition walls are also given, in addition to a number of interesting tests, with photographs, which have been made to demonstrate to architects in various parts of the world the additional strength given to walls when reinforced with H. B. patent wire mesh. The catalogue also includes examples of the different thicknesses of walling, with useful tables for calculating the cost of construction, and the weight and volume of various substances.

Edwin J. Pearce & Co., Ltd., Leicester, have published a well printed and artistic list, showing coloured illustrations and drawings of their various specialities, as well as photographs of work executed by them in reinforced concrete. Among the advantages which the firm claim for their reinforced concrete fireproof and soundproof floor, are lightness, strength, rapidity and ease of erection, also that the cost of centering is saved, this not being required. The flooring slabs are made in lengths of 4 ft. and are about 1 ft. 6 in. wide. They are recessed at the ends to fit on to the bottom flange of the light steel girders, space being left for a grout of cement to protect the flanges of the girders. Messrs. Pearce & Co. are able entirely to finish off all work which they undertake, as they make a special point of their wood block and parquetry floors, Roman and Venetian mosaic work, etc.

The (U.K.) Winget Concrete Machine Co., Ltd., of Northumberland Street, Newcastle-on-Tyne, have just received from one of H.M. Government Departments a further order for another "Winget" concrete machine, complete with ordinary outfit, pallets, etc. There could be no more convincing proof of the merit of these machines than the fact that Government Departments are giving repeat orders for them.

James H. Tozer & Son, Ltd., of York Mansion, York Street, Westminster, have asked us to state that Mr. Percy Tomey is no longer in their employ as agent, engineer or manager of the Reinforced Concrete Department.

W. & G. Foyle, 135 Charing Cross Road, W.C., have sent us a copy of their new catalogue of technical and scientific books, and call attention to the fact that nearly all the volumes included therein may also be obtained from them second-hand, at about half the published prices. Any book will be forwarded on approval.

Edward Lomer & Co., Ltd., of 110 Fenchurch Street, E.C., have been appointed by Gauhe, Gockel & Co., of Oberlahnstein, Germany, as sole representatives in the United Kingdom for the sale of their builders' and contractors' machinery and appliances, concrete mixers, etc.

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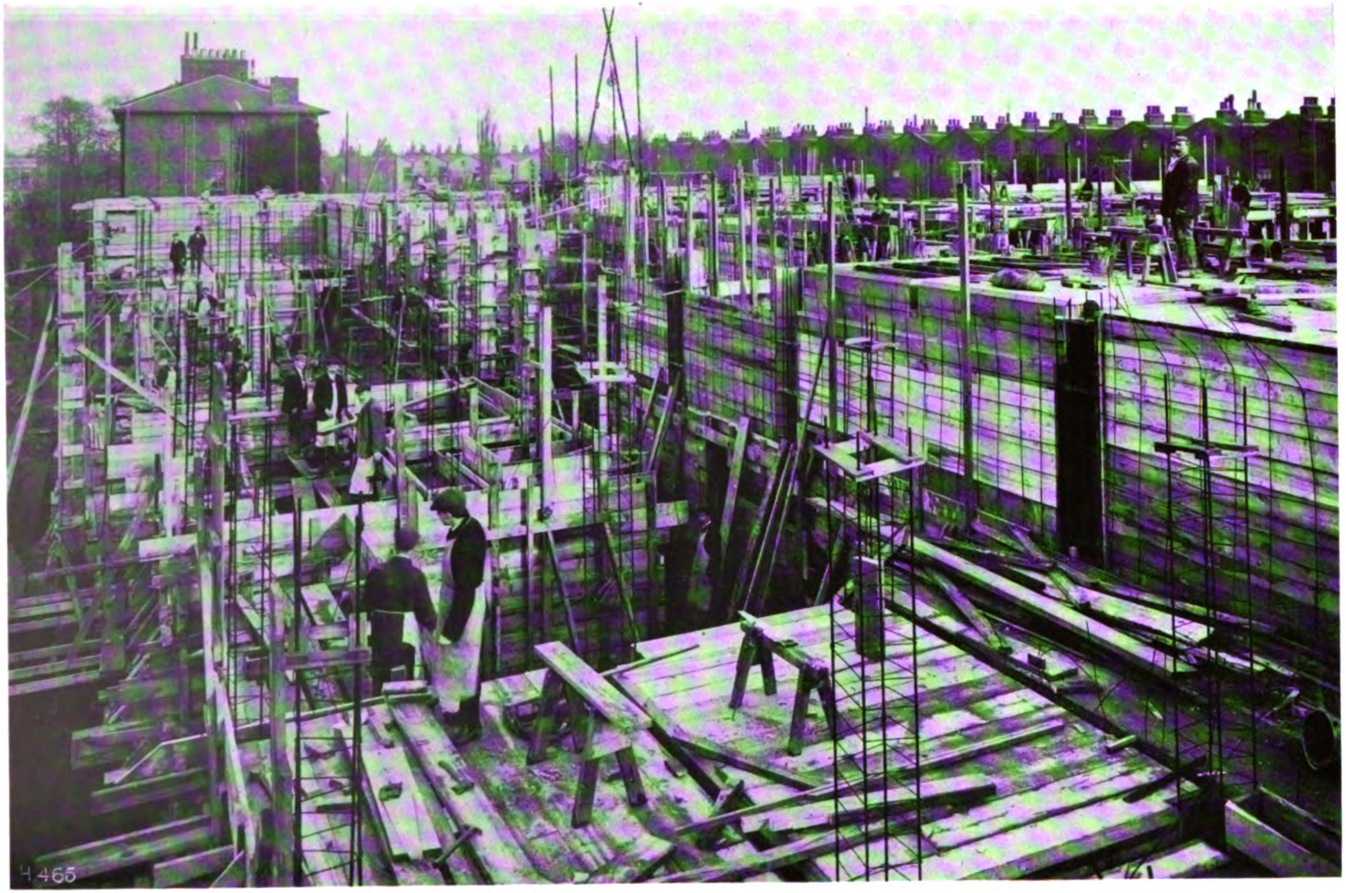
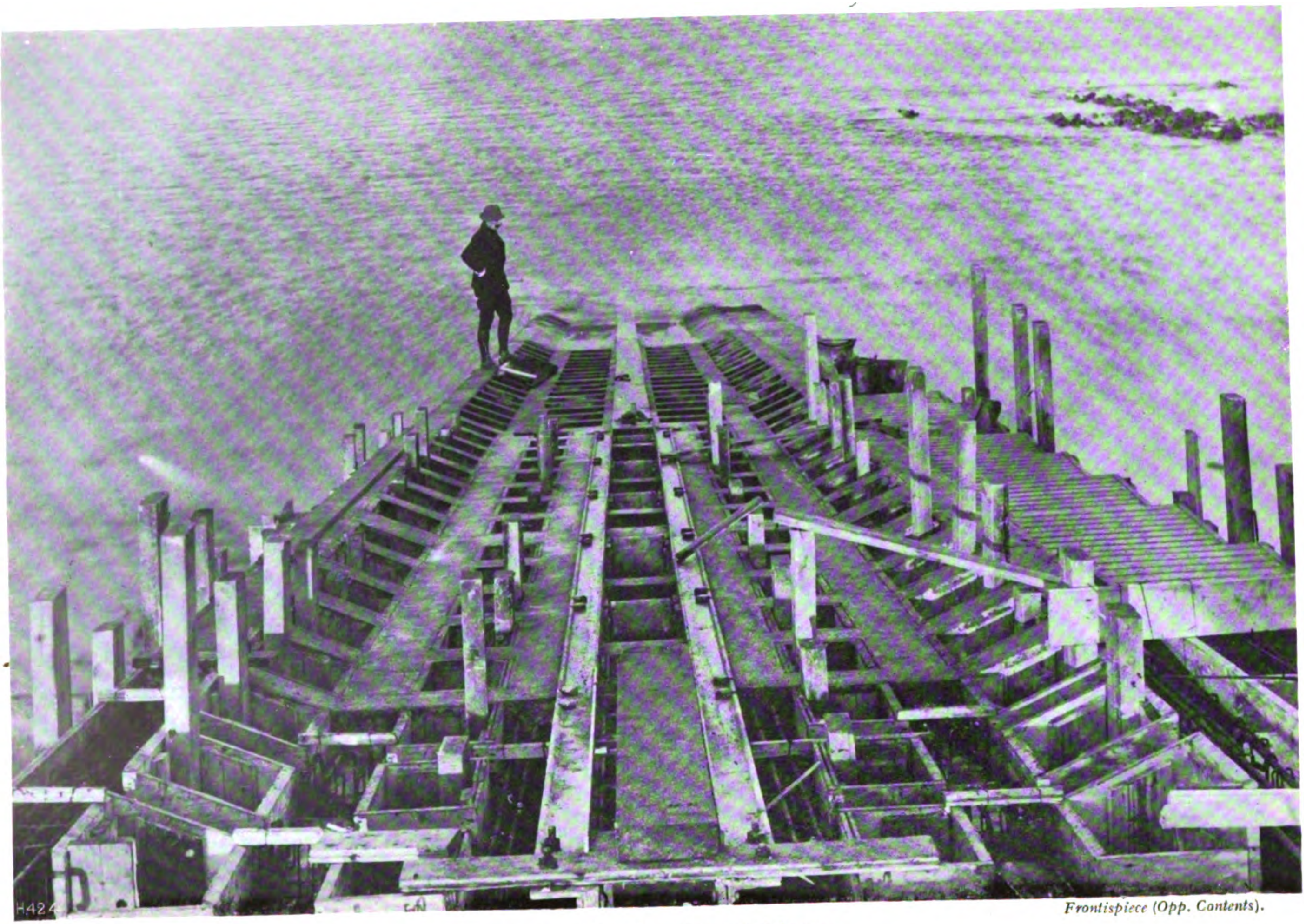


View showing centering for the pillars, floors and walls under first floor.

New Money Order Offices at Holloway.

Frontispiece.
(Opp. Contents.)



Frontispiece (Opp. Contents).

View looking down from shore end of slipway.

REINFORCED CONCRETE LIFEBOAT SLIPWAY AT ACKERGILL.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 4. LONDON, APRIL, 1910.

EDITORIAL NOTES.

REGULATIONS FOR REINFORCED CONCRETE.

IN the present issue we are presenting an interesting contribution on the question of regulations for reinforced concrete in the metropolis from the pen of Mr. William Dunn, F.R.I.B.A., whose views we invited on the subject.

It may be remembered that Mr. Dunn was one of the leaders of that enthusiastic band of opponents to the London Building Act Amendments last Session, when the question of the regulations for steel frame structures was before the House of Commons. Mr. Dunn's views were generally adverse to the regulations, and the detailed regulations in particular, and neither the Building Act nor its administration seems to find much favour in his eyes.

It is always of considerable value to be able to present views seriously given on a subject of this kind, no matter how much we may disagree with them, for, in the first place, arguments such as Mr. Dunn's may influence those in authority against over-regulation, and on the other hand they show those same authorities the dangers of the absence of proper regulations.

The arguments put forward would, of course, be very much in place if the Code Napoleon were in force in this country, and the responsibility, both personal and pecuniarly, were definitely defined so far as building owners and architects were concerned, and the first result of any accident were, as is the case in some countries, immediate imprisonment of those controlling the building operations, who are, *ipso facto,* assumed to have been negligent until they can prove their innocence. The Code Napoleon, however, is not in force in Great Britain, and—as long as the pecuniary and personal responsibilities are not clearly defined by a legal code—detailed regulations are absolutely essential in our view if the public are to be safeguarded against carelessness or ignorance on the part of those who undertake the erection or supervision of the construction of buildings.

We belong to those who consider the Amendments to the London Building Act of last year to be excellent precautionary measures and very practical ones, except in the matter of a few details. We shall welcome a detailed code of regulations under that same Building Act Amendment dealing with reinforced concrete.

We consider the public are amply guarded against any over-regulation on the part of the London County Council by the fact that the Local Government Board must approve the proposed regulations and have to consult various technical societies regarding their utility.

We certainly hold that the regulations, when framed, should cover all reinforced concrete used in a building, whether internal or external; and in advocating the careful regulation of reinforced concrete in the metropolis we think that this will be a great safeguard for the reinforced concrete industry, which is still very much in its infancy.

The first serious accident to a reinforced concrete structure in the metropolis, involving loss of life, would mean a set-back for this industry, not only in London, but throughout the entire country; and everything which can be done within reason to prevent such an accident should be done by the authorities on public grounds, and should also be looked upon as beneficial to the professions and industries concerned.

As to some of the more general remarks of Mr. Dunn in his able article regarding the building regulations, and their administration in the County of London, our view is, taking the capitals of Europe generally, that it is easier for the building owner and his professional advisers to get to work in the metropolis than anywhere else; and, speaking generally, that the administration of the regulations by the district surveyor on the one hand, and by the London County Council and its principal officers on the other, is equitable, efficient and courteous. In fact, it is far less irritating to the building owner and the architect than in any other capital.

Regardless, however, of our views on this subject, we recommend Mr. Dunn's article to the attention of our readers as a most useful contribution on the subject, and we invite their correspondence in reply to the arguments he so ably puts forward.

CEMENT TESTING.

A VERY interesting paper relating to the testing of Portland Cement was read by Mr. D. B. Butler, F.C.S., at a meeting of the Concrete Institute on March 17th, in which was raised again the very important question of the relative value of the methods in vogue for determining by accelerated tests the soundness of cements for constructional work.

From the title of the paper we note that the test selected for criticism was that of Le Chatelier, which test enables a quantitive determination of the qualitative eccentricities in regard to the expansive properties of Portland Cement to be made.

The test is still one of the principal features of the British Standard Specifications for Cement, and we understand that, notwithstanding its severity, it has been accepted by all manufacturers of repute, the product of whose works has been much improved by their successful endeavours to comply in detail with the requirements of this test.

In our issue of July, dealing with Mr. H. K. G. Bamber's paper on "The Setting of Portland Cement," we published a report on a similar subject, in which the opinions of Monsieur Le Chatelier himself were expressed on points of criticism of his method which were then raised, and in the course of his recent lecture Mr. Butler makes reference to points raised in this earlier paper and reports the results of some very carefully conducted experiments, which in the main confirm the conclusions arrived at by others who have earlier dealt with this subject.

There appears to be a variety of opinions as to whether this test, together with others which Mr. Butler enumerates, errs on the side of severity as compared with the method adopted by the late Mr. Henry Faija.

The author of the paper, who has a wide experience in these matters, deals with his subject in a most able manner, and inclines to the retention of the less severe tests of the past, and one cannot help realising that cement used in the past which would not comply with such severe tests as the Le Chatelier have not all proved faulty in construction.

For ourselves, we incline to the more searching tests of the Le Chatelier methods, especially as they do not seem to impose any particular hardships on the manufacturers, and the user should undoubtedly prefer to use a material which had passed the greater rather than the lesser test.

THE HOLLOWAY MONEY ORDER OFFICE.

It is with great pleasure that we are again giving some particulars of Post Office work executed in reinforced concrete under the direction of His Majesty's Office of Works. In this instance the building is for the Money Order Department at Holloway. These continued examples of structures in the new material executed for our public departments are far greater evidence and testimony to the utility and economy of reinforced concrete for general purposes than any amount of argument or special pleading on our part.

THE NATIONAL ASSOCIATION OF CEMENT USERS.

The National Association of Cement Users of America, of which Mr. Richard L. Humphrey, M.Am.Soc.C.E., is the President, held their sixth annual Convention at Chicago from February 21st to the 25th. The Association are certainly to be congratulated on the success of the Convention, the meeting being the largest ever held by the Association, over 350 members attending.

The papers presented were more than usually interesting, and we regret that they came to hand too late for insertion in this issue. We shall, however, deal with them at some length at a future date.

Reinforced concrete was given its usual prominence in the proceedings of the Association, and a great deal of the time of the Convention was devoted to the discussion of proposed standard specifications, the most important being regulations for the use of reinforced concrete, which were accepted by the Convention, but which now have to be submitted to the Association as a whole.

The President was particularly anxious that members should endeavour to spread the knowledge of the Association's standards, and we shall publish the reports and discussions on these at a later date for the benefit of our readers, as the standardisation of methods is a matter of great importance, especially in the case of a new industry such as reinforced concrete; and we think that there should certainly be co-operation, wherever possible, between English and American engineers and architects on this matter.

PORT OF LONDON DUES.

Effect on the Cement Trade.

THE Port of London, the largest shipping centre in the world, was for many years hampered in its development by lack of adequate funds. The administration was in the hands of various bodies, and the docks were, to a large extent, out of date. From time to time various proposals have been made to get over the difficulty. The various dock companies were unable to raise more capital, having failed in the times of prosperity to provide adequate reserve funds for the renewal of obsolete plant and the proper maintenance of their undertakings. Various enquiries were held from time to time, and at last, in 1908, an Act of Parliament was passed vesting the entire control of the port in the hands of a body to be elected by the various interests concerned, and providing for the purchase of the docks.

Hitherto London, though a dear port for shipping, has enjoyed the great advantage of entire freedom from dues on goods. In order to provide the revenue for the necessary expenditure to thoroughly equip the port by bringing the existing docks up to date, constructing a new dock, and improving the Channel, Parliament has authorised the levying of import and export dues.

The Port Authority recently issued a schedule of the proposed dues which brought forth loud protests from all circles. The Board of Trade appointed Lord St. Aldwyn to hold a public enquiry, and the various objectors have been urging their case before him. The interests are so diverse and conflicting that it was soon apparent that no settlement could be arrived at which would be satisfactory to all parties.

The case for the cement trade and allied industries was taken up by the Cement Section of the Chamber of Commerce, who appointed its chairman, Mr. Charles Charleton, of Messrs. I. C. Johnson & Co., and Mr. Alfred Brooks, one of the managing directors of the Associated Portland Cement Manufacturers (1900), Limited, to appear on their behalf.

The total value of the imports and exports of this trade amounts to about £2,200,000 per annum, and the contention put forward was that the contribution from this traffic, which only uses the docks to a comparatively small extent, should approximate the average levy from the whole trade of the port, which would involve an average charge of about £1,500. The schedule provided for a maximum rate totalling £19,000, but it became apparent as the enquiry proceeded that the actual rates which would probably be levied would amount to about £8,000. Considerable reductions were secured on various items, but upon coal a reduction of only 1d. per ton was secured, and the rate on cement itself was not altered, so that the trade will have to bear an annual burden of about £6,000, unless more favourable consideration can be obtained when the matter again comes before Parliament when the provisional order is presented.

REGULATIONS FOR REINFORCED CONCRETE BUILDINGS IN LONDON.

By WILLIAM DUNN, F.R.I.B.A.

In presenting this article by Mr. William Dunn we would refer our readers to our Editorial on the subject, from which it will be seen that, whilst we are not in agreement with the Author's views, we consider that the article deserves careful attention, as an argument by one of those members of the technical professions whose views are against regulations.—ED.

UNDER the General Powers Bill, 1909, the London County Council may prepare regulations governing the erection of buildings or parts of buildings in Reinforced Concrete, and it is generally understood that the officers of the Council are now engaged in drafting the proposed rules.

I conceive that those responsible for the new regulations, whether as members or officers of the Council, or the Societies which are to be consulted before those regulations become law, may profitably consider the objects and limits of such enactments—what things should be governed by the law and what are best left to the individual.

The proper limits of the function and duties of Government must always be uncertain, to be settled rather by the weight of argument in particular cases than by abstract principles. But we must call to mind the evil results which arise from the acceptance of rash proposals made by sincere lovers of improvement, frequently intensifying the very evils which they sought to remedy. There is the "Merchandise Marks Act," requiring goods to be stamped with the name of the country of origin, which is said to have lost us some of the trade it was designed to improve; there is a Bill for the protection of workmen in a particular industry, by restricting their hours of labour, which, after some experience, does not seem to improve the workman's condition; there are the "Model Bylaws," advocated, with the best intentions, as a method of securing good and healthy homes for the poor. We know that the Bylaws have operated rather adversely, by keeping the country people in old and insanitary houses, because few can afford to build in the manner prescribed. The results in this case are now so well known that many of the requirements as to walls and details of construction have been abandoned.

Under these Bylaws, however, there is a safeguard of some value to the individual, in that the "Summary Judicature Act" gives the magistrate before whom appeals are heard power to hold any bylaw in any particular case unreasonable, and to decline to convict.

The County Council are now to make regulations which differ in some subtle way from bylaws, and it will be very desirable for all interested to see that there is some appeal from the Council's decision.

The British dread of that extension of the province of Government which Continental peoples welcome, both in theory and practice, is gradually breaking down, especially in regard to building. A Vice-President of the Royal Institute of British Architects, Mr. J. W. Simpson, in a very able letter to *The Times* on the "London Building Acts Amendment Act of 1905," called attention to "the appalling list of Acts regulating building in London," quoting some eleven different Acts. We have now a twelfth in the Act of 1910, not to speak of "those countless bylaws, schedules and regulations on every conceivable subject—from the laying out of streets to lamps and clocks, and the exact pattern of caulking for an iron pipe—to the rather darkening of the understanding" (I quote from Mr. Simpson).

That we are to have yet another set of regulations, with all the force of law, is due to the necessity of freeing us from restrictions which should never have been imposed.

Just as in the daily conduct of life there is much which falls short of a high standard—nay, much which is worthy of reprobation, yet not subject to legal restriction, because the general opinion of our people has hitherto been that the evils of over-government are greater than those arising from too much liberty—we may fully agree that some method or material is the best, and yet strongly object to its use being made compulsory. For such a best may be but temporarily so, until another appears; and occasions may arise in which that "best" is undesirable or a sheer waste of money.

No fixed rules or regulations can take account of all the circumstances or cases which may arise, and it is not an uncommon experience to find that the District Surveyor has to insist upon something being done which he is quite willing to admit is unnecessary or would be better left undone.

We know how the development of reinforced concrete construction in this country has been kept back by our building laws. The earlier London Building Acts formed the model for the laws in all our English and Irish towns, and, as they did not recognise that concrete could be strengthened by steel, the administrators of them had no choice but to require the same thickness of wall for reinforced concrete as for plain concrete. Fortunately the earlier Acts were confined to matters affecting party walls, external walls, the prevention of fire, and other such things, so that we were free to work out and use reinforced concrete in internal construction

In many cases it forms the cheapest, the most stable, most sanitary, and most fire-resisting method. To debar the community from using it in any way for which it is fitted, as for external walls, is a loss to the country for which there is no corresponding advantage.

In my view we should be careful to avoid any extension of restrictions on building not absolutely essential for one or other of the objects for which Building Acts are required—for the prevention of the spread of fire, for public health, or public safety.

Building Acts should not contain specifications, but be confined to such general requirements as are necessary under one or other of these headings. During the discussions on the clauses relating to steel construction, in the

London County Council General Powers Bill, 1909, the building codes of American cities were frequently cited as examples to justify the inclusion of minutely detailed rules. At that very time it happened that New York had undertaken a revision of its building code, and the Press and professional men of New York were endeavouring to amend it, citing on their side the absence of minute detail in European laws. Thus the *Engineering Record* of July 24th, 1909, says:

> The Building Code discussion that has been taking place in New York for some months has resulted in some forceful comments on the general type of building code so prevalent in this country. For some reason or other which it is difficult to ascertain, our building codes are gradually becoming building specifications rather than regulations for the purpose of enabling owners to secure safe structures at a minimum expense. The difference between the elaborate details of the average American code and the building regulations of leading European cities is a striking one. The foreign regulations stipulate merely those features of engineering practice which must be followed in the design, leaving the architect and engineer to elaborate the details of their plans in accordance with such rules. Here it is becoming customary to adopt regulations covering many other things than the principles of safe design, and as a consequence the complexity becomes so great that, even with the best of intentions, grave injustices may be done to property owners by discrimination against certain forms of useful construction or in favour of certain classes of material. It is difficult to comprehend, in fact, how a code of such complexity as that proposed for the City of New York can be drawn, even by a board of experts, which will not be subject to strong criticism as favouring or disfavouring some form of design or construction which experienced specialists consider perfectly suitable. It is only necessary to recall how opinions have differed in debates before the American Society of Civil Engineers on standard specifications for steel structures, to appreciate that a building code, covering in the same way a great number of materials other than steel, is bound to be the subject of strong criticism. While this journal does not believe that American engineers should turn to Europe for precedents in all manner of engineering and architectural matters, it is strongly of opinion that we have a great deal to learn from the building codes of the Continent. By adopting the simplicity of these foreign codes the likelihood of favouritism, intentional or unintentional, towards certain forms of construction would be largely avoided.

The Concrete Institute, the Institution of Civil Engineers, the Royal Institute of British Architects, and other societies, spent their funds freely, and members gave their valuable time, in endeavouring to secure greater freedom and to save the ratepayers unnecessary burdens in regard to steel construction, and succeeded in so altering the Bill that, whereas the Council sought uncontrolled power (a power which would be exercised not really by the Council, but by its officials) to make regulations governing reinforced concrete, its proposals must now be submitted to the great representative institutions and obtain the sanction of the Local Government Board before they become law.

I would appeal to those responsible for the drafting of the regulations, and to the Institutions who are to be consulted, to agree in making these the governing ideas:

(i.) That the object of the regulations is to give the citizen the power to use reinforced concrete for walls.

(ii.) That the use of it should be hampered by as few restrictions as possible.

(iii.) That the regulations should not take away any freedom we now have, but remove restrictions only.

In that well-regulated country, Germany, there are minute rules for reinforced concrete, as for most other things. I do not regard that country as affording a model in all things, and I hope that, instead of endeavouring to *include* every possible rule, our aim will be to *exclude* every rule not absolutely essential in the public interest. The individual is usually the best judge in matters affecting himself; let us not take away from him, with his freedom, that responsibility for his actions which would largely go if every detail of construction had to have a Government stamp of approval.

I understand that in Germany the architect and builder escape readily from responsibility if they can show compliance with the building regulations. In France, on the other hand, the building regulations are of the simplest character, but the responsibility of the architect and builder remains for a definite period of years. In England we have the burdens of both countries.

The use of reinforced concrete for floors, pillars, stairs, roofs, etc., has steadily developed, without any such series of accidents as would call for special restriction, and without proving that the trade of the reinforced concrete constructor is a dangerous one, to be specially regulated by Act of Parliament.

The London County Council, under section 23, sub-section 1, "may make regulations with respect to the construction of buildings wholly or partly of reinforced concrete, and with respect to the use and composition of reinforced concrete." It is to be hoped that the clause 27, inserted at the instance of the professional societies, which enacts that "nothing in this part of this Act or in any regulations in force thereunder shall take away or prejudice any powers, rights, privileges or exemptions vested in or enjoyed by any person under the principal Acts or any of them," will enable us to keep the freedom which we have in the matter of floors and the interior work of buildings generally.

I am strongly of opinion that it is a mistake to throw upon public officers duties which they cannot effectively perform, or to make laws which cannot be enforced. We might insist upon the most carefully calculated and detailed drawings, but that would give no real assurance of the safety of the structure. This must always depend very largely on the quality of the ingredients, their proper admixture, and accurate use, which can only be secured by the employment of skilled workmen and by constant supervision, such as no public officer can give. The real safeguard lies in the responsibility of the builder, architect, and owner, and anything which would weaken that responsibility is to be deprecated.

Even if there were general agreement on all points, it would be a mistake to formulate bylaws in much detail. For instance, a few years ago, when the Joint Committee of the Royal Institute of British Architects was engaged on the report, the system of strengthening columns by lateral binding or helical reinforcement was not in general use, though warmly advocated by a few men. In the report the stresses in pillars were assumed to be borne by the concrete and the longitudinal reinforcement, and no proposals were formulated for the extra strength given by the lateral binding. During the two years which have elapsed since the publication of that report the use of helical reinforcement or lateral binding has become the more usual method. If the Council had adopted the Joint Committee's report as the basis for its rules and gone into the same detail, enacting the suggestions therein as regulations, we should probably now be unable to use helically reinforced columns until the L.C.C. regulation could be altered. During the debates before referred to it was said by the officers of the Council that there was the greatest difficulty in making alterations in the Council rules.

The British Committee on Reinforced Concrete is at present sitting to enquire whether any amendment or revision of its report is desirable; but that Committee can readily alter for cause shown. Not so the London County Council, and it behoves us to be very careful in agreeing to anything. We must see, if possible, that there is some ready means of altering when occasion arises.

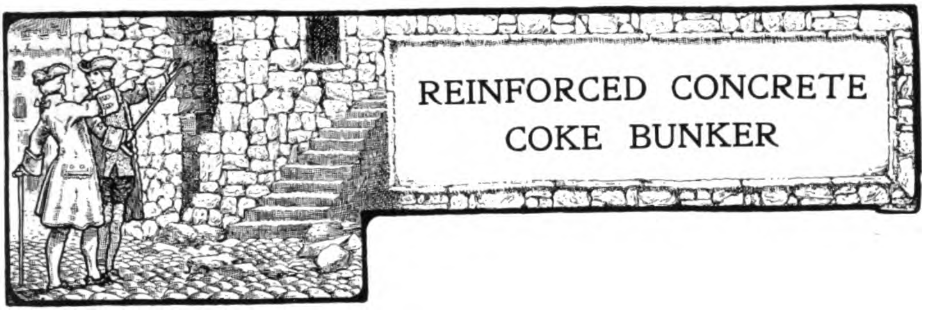
It is also to be hoped that no excessive fire protection is required. In the clauses of the "General Powers Bill of 1909" relating to steel construction, all steel girders and pillars in the *exterior* parts of buildings are specified to be covered with at least 4 inches of fire-resisting material, but the casing to the under side and to the flanges may be made *two* inches thick, this section not applying to the case of buildings not more than 25 ft. in height. All other pillars and girders, except subsidiary joists, are to have a similar casing of 2-inch thickness. A girder is defined in section 21 as "a metal girder or joist," but what a "subsidiary" joist is is left to be argued with the District Surveyor. In reinforced concrete work the metal is less liable to injury by fire, as it is not in large masses, but distributed through the concrete, so that a less cover will give the same protection.

One can readily understand that a small round rod, of which only one point is within one inch of the external face, has a more efficient protection than a flange of a girder at a greater distance back. For the flange may be any width, from 3 to 18 inches, and the stripping of a small part of the covering leaves probably the whole width of flange exposed. Then in a girder or joist, except in the case of small floor joists, there is often an air space round the web, metallic lathing being used as a base for the fire-proof covering. In such a case there is greater conductivity, and the effect of a local heat is not so much confined to the part exposed. It must be remembered that any regulations for covering the steel with concrete define the minimum, and for many buildings the fire risk is slight.

There is also the question of testing the structure or the materials. It might prove a most serious burden to builders if the District Surveyor is given the power to require the builder to make any tests which the surveyor considers necessary. Under that part of the 1909 Act dealing with steel skeleton construction, as originally drafted, the surveyor had power, not only to drill pillars, but " to cause to be made any other tests he may consider necessary." Under the Act as passed this has been so rearranged that the making of tests appears to be confined to the quality of the materials. If the District Surveyor were empowered to require the builder to load up floors, roofs or pillars, in order to satisfy himself of the strength of the structure, the cost might be ruinous. The writer has not met a District Surveyor who would use this power oppressively in a wilful manner, but it *might* be used oppressively from sheer nervousness, want of confidence, or fear of responsibility.

Presumably the Council will also require that plans, sections, details and copies of calculations in full detail be submitted to it, it may be in duplicate, on tracing linen, traced on the dull side of the paper, and so on. The amount of drawings to be submitted to the Council, the District Surveyor, and others, is considerable at present. For instance, if it is a question of a reinforced concrete warehouse, there will be the special application with full details and calculations; there will be another set for approval of means of escape in case of fire; there must be plans for the local authority, showing the drainage scheme, for their approval; there may be plans for variation in the cubical extent or for variation in the size of the openings in party wall, or for alteration in the line of frontage, or for approval of plans by the freeholder. The County Council may, in one capacity, gravely inform us, under the hand of its superintending architect, that it approves the plans, and immediately thereafter, in another capacity, by the same hand, inform us that the plans are *not* approved! Every obstacle of this kind affects most seriously the cost of building, by reason not only of the expense in preparing so many drawings, but also by the serious delays which take place in obtaining the approval of the Council. A delay in building entails loss of interest on the value of the site, which in London is an important part of the outlay.

To the architect or engineer the preparation of all these applications requiring their labour brings more work and more fees, but it is the unfortunate person who builds and the unfortunate ratepayer who pays for the staff of officials, busily engaged in saying " Don't," who are to be pitied. It is the citizens of London who suffer by over-legislation such as I know of in no other city, but, unhappily, they never hear of Building Acts or bylaws until they proceed to build, and learn with astonishment that in the eye of the law the man who wishes to build is full of wicked instincts, requiring very special repressive treatment.



REINFORCED CONCRETE COKE BUNKER

We are pleased to be able to give detailed particulars and drawings of a large Coke Bunker at Dunfermline, executed in Reinforced Concrete, as it shows very clearly how practical this material is for such work. The drawings were put at our disposal by the consulting Engineers—Messrs. F. A. Macdonald & Partners, of Glasgow.—ED.

THERE has recently been erected for the Dunfermline Gas Commissioners, at their gas works, Dunfermline, a large reinforced concrete coke bunker, which presents some unique features in constructional work, and particulars of the design of which we are enabled to give by the courtesy of the consulting engineers.

The intention of the Commissioners, in the first instance, was to have used steel columns and steel longitudinal girders, but on the suggestion of the consulting engineers this was departed from and a monolithic reinforced concrete structure adopted.

The bunker has been constructed over two lines of railway sidings, the one passing directly beneath the bunker being used for discharging into a receiving bunker below ground level, and also for loading into railway truck from the large reinforced concrete bunker above, and the other, passing below the outer reinforced concrete cantilevers, being used for ordinary siding purposes, and also for loading purposes from the reinforced concrete bunker.

While traffic was suspended for some short time, during the construction of the bunker, on the railway siding immediately beneath it, the outer railway line had to be kept clear for traffic during the whole period that constructional operations were in progress, thus adding materially to the practical difficulties of the work.

This difficulty was, however, overcome by the special method of dealing with the centering, as suggested by the consulting engineers and successfully carried into operation by the contractors.

At the top of the bunker, and supported by the large reinforced concrete stay beams shown in *Fig.* 9, there has been constructed a receiving hopper, and also a reinforced concrete bottom for another storage hopper for breeze, and the total weight of contained material, on which calculations for the design of the structure were based by the consulting engineers, was 350 tons of coke in the large bunker and 40 tons of breeze in the breeze hopper, in all 390 tons over and above the self-weight of the structure.

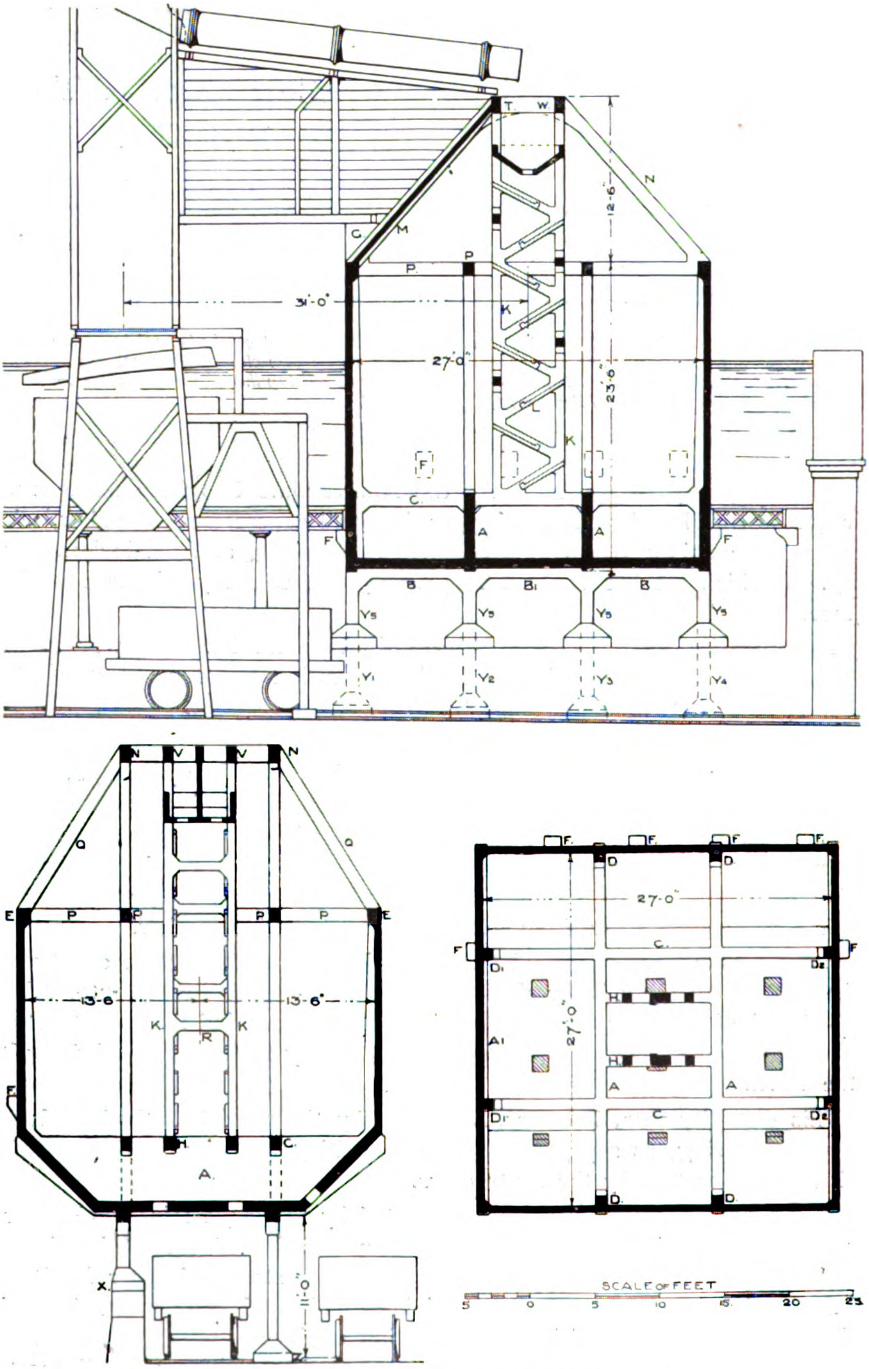


Fig. 1. Plan and Sections of Hoppers.

In addition to these loads, it will be observed from the general drawings that reinforced concrete brackets have been constructed, monolithic with the main bunker walls, to carry the loads arising from the roof principals and roof girders of the adjoining buildings.

The coke is fed into the bunker by means of a revolving screen, erected on a platform adjoining the main bunker at summit level, which platform partly obtains support on the reinforced concrete structure.

To enable the coke to be dropped from this revolving screen into the main bunker without being broken, and also to form a support for the end of the coke screen, a reinforced concrete structure has been constructed within the main bunker, comprising four reinforced concrete columns, braced together with diagonals and supporting a series of inclined and graduated reinforced concrete slabs, each slab so formed as to be slightly concave on its upper surface, and down which series of slabs the coke will flow, eventually heaping up within the storage bunker at its natural angle of repose.

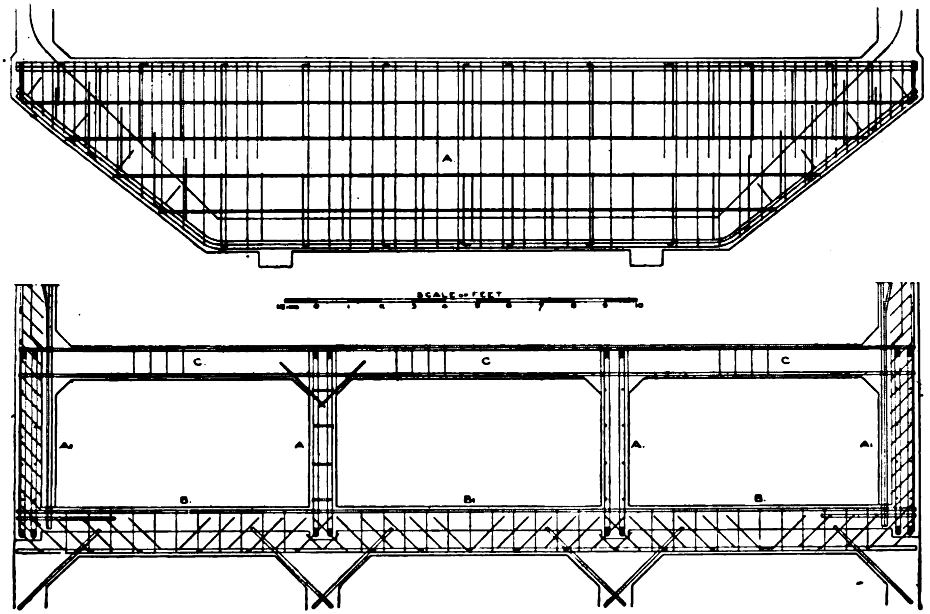


FIG. 2. ELEVATION AND CROSS-SECTIONS OF LARGE CANTILEVER BEAMS.

At the summit of the main structure, as mentioned, there has been constructed a receiving hopper. This hopper has four openings, fitted with hinged steel plates. These hinged plates will be kept closed until the coke in the main bunker reaches to the level of the slide doors, when they will be released, thus enabling the bunker to become completely filled.

Inclined reinforced concrete beams have been introduced in the design for the purpose of staying the summit of the structure. It will also be noted that the space between two of the large arched stay beams has been filled in on one side with a reinforced concrete slab, thus forming the bottom of the breeze hopper.

The whole arrangement is one of particular efficiency and ingenuity and is shown on the drawings accompanying this article.

It will be noted that the position of the main columns in the transverse direction is limited by the presence of the railway sidings, which existed prior to the construction of the bunker, and this also necessitated the cantilevering out of two sides of the bunker beyond the columns as shown, thus complicating the problem of design.

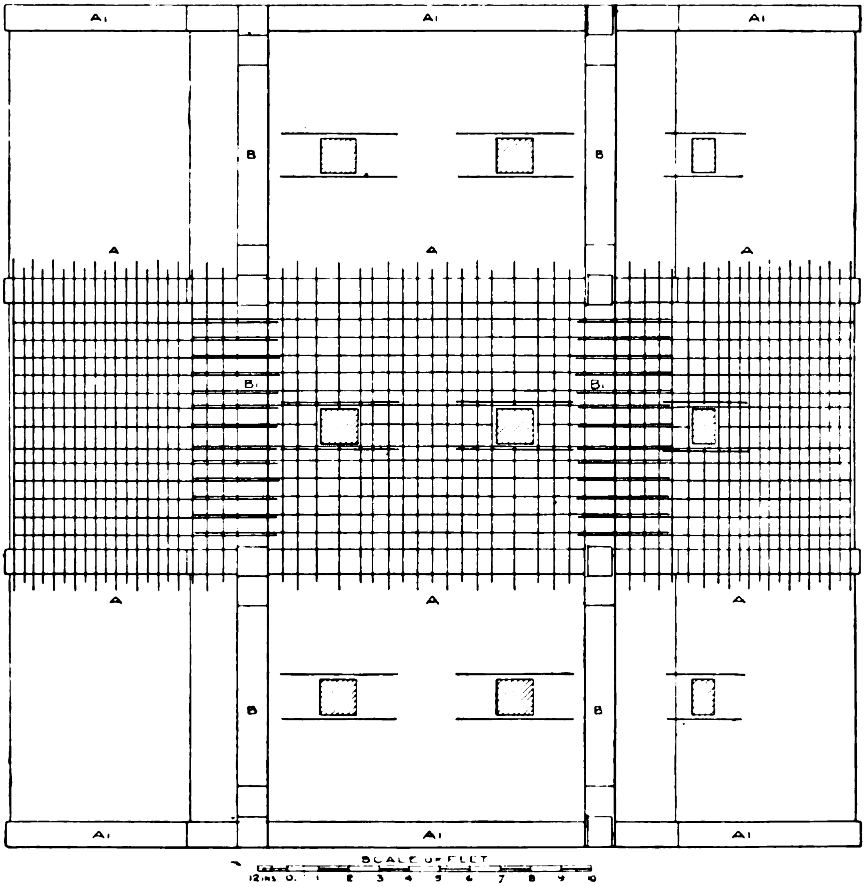


Fig. 3. Plan of Reinforcement of Bottom of Bunker.

The reinforced concrete columns on the one side are 12 in. by 12 in. section, and are supported on reinforced concrete bases, the loads from which are again spread by means of a special beam along the length of an existing masonry wall, constructed as a retaining wall and having a minimum breadth at top of 2 ft. 6 in.

On the other side the breadth of the supporting columns was necessarily limited on account of the Board of Trade regulations for clearance of railway traffic, and the section adopted was 12 in. by 9 in.

On this side also the loads from the columns are received on reinforced concrete bases, and the loads again spread by means of a special beam.

The ground under this line of columns was found to be of the nature of "forced" material for a considerable depth, and this difficulty was dealt with by excavating a broad trench down to the hard, the trench being timbered in the usual manner, and after the excavation was complete the trench was filled up solid with lime concrete, thus practically forming a continuous wall.

Above this wall of lime concrete the special beam already mentioned was constructed, and after completion of this foundation beam the construction of the column bases and columns was proceeded with.

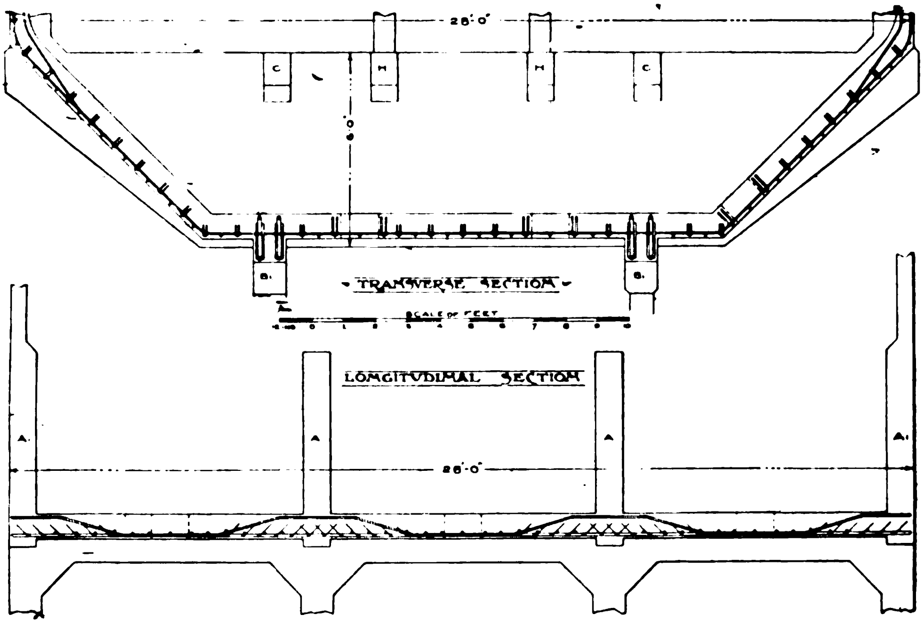
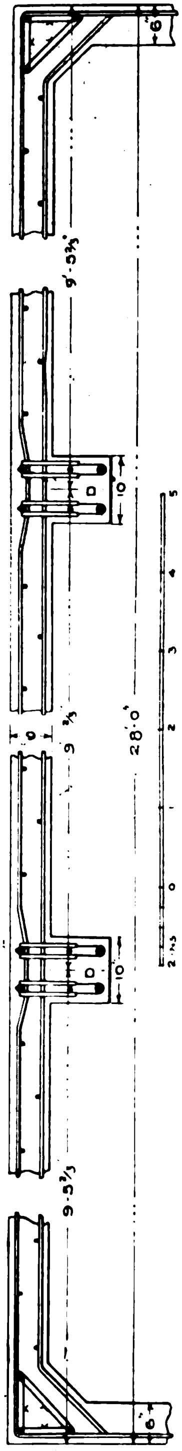


FIG 4. SECTIONS OF REINFORCEMENT OF BOTTOM OF BUNKER.

Figs. Nos. 3 and 4 show the method of reinforcing the bottom of the bunker, which is 9 in. in thickness, and supported on the main reinforced concrete cantilever beams running transversely, and on the reinforced concrete T beams B1 running longitudinally.

The method adopted by the consulting engineers of reinforcing the bottom of the bunker, which has an enormous load to carry per square foot of area, is exceedingly interesting.

Details of the large cantilever girders A are reproduced, both in elevation



Sectional Plan of Walls, Showing Buttresses D.

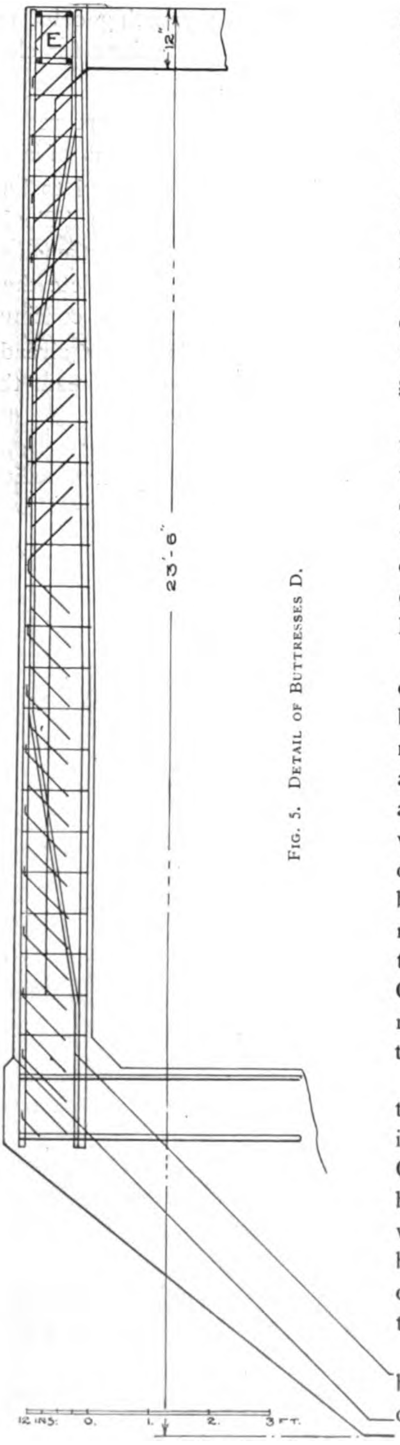


Fig. 5. Detail of Buttresses D.

and cross section, see *Fig.* 2.

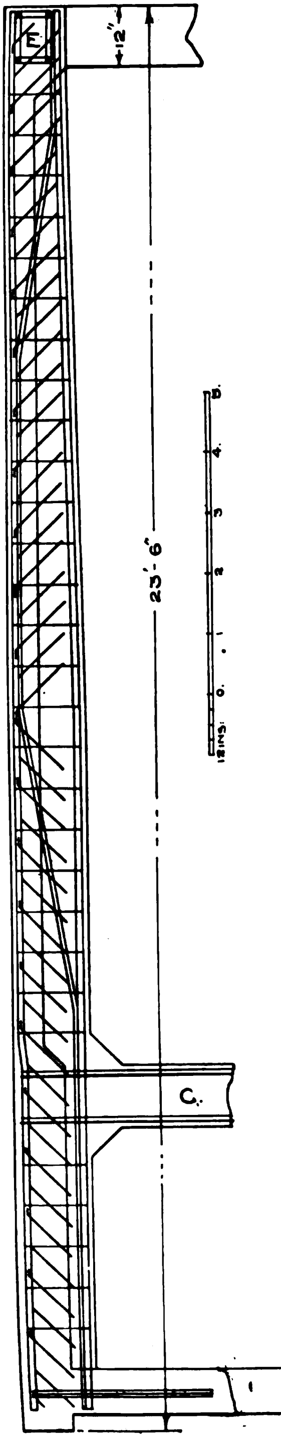
These girders at their maximum section are 6 ft. in height, and the disposition of the reinforcement shows clearly the very effective character of the reinforcement in connecting the axes of tension and compression throughout the web of these enormous girders.

It will also be noted that these girders, in addition to the load arising from the contained coke, have also to carry the deadweight of each outer side wall at the extreme end of the cantilever.

The main reinforced concrete girders, A, are braced top and bottom by reinforced concrete beams at right angles thereto; at bottom by beams, B1, which in addition to being calculated and designed as beams, are also further reinforced as struts and ties; and at top, by struts C, which are designed and reinforced as struts and ties.

It will also be observed that certain of the reinforcing bars of beams, B and C, are hooked round the buttresses, D, of the end walls, the section of such bars being calculated to enable them to act also as ties, as well as struts.

The outer walls of the bunker, resisting the thrust of the contained coke, are



Detail of Buttresses D1 and D2.

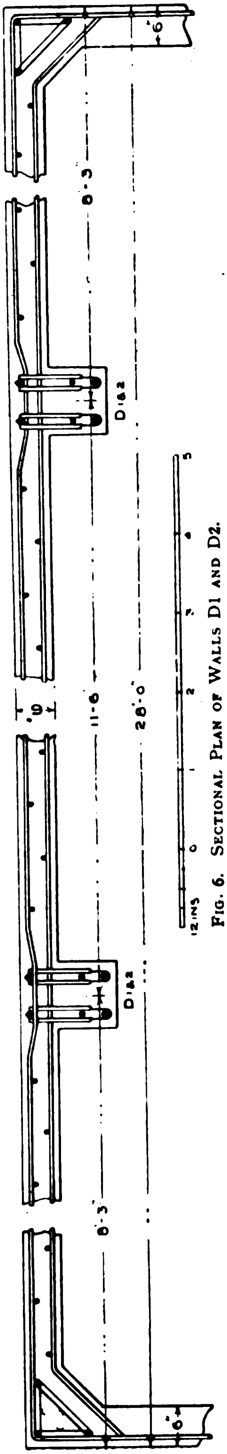


Fig. 6. Sectional Plan of Walls D1 and D2.

6 in. in thickness, and their span in the horizontal direction is lessened by the introduction of buttresses or vertical beams, D, details of the reinforcement of which we reproduce in *Figs.* 5 and 6.

These vertical beams, D, are held at bottom by the tie beams, C, as mentioned, and at top are received into beams, E, which are again held by the beams, P.

We also reproduce details (*Fig.* 9) of the large arched stays, N, at the summit of the structure, showing the effective trellised girder arrangement of the reinforcement, and these arched stays are again strutted in the other direction by the inclined beam, Q, springing from beams, E, to the summit of the arched stays.

For the formation of the bottom of the breeze hopper, an intermediate inclined beam, M, has been introduced between the arched stays, as shown by *Fig.* 9.

The internal structure for ensuring the downward gradual flow of the coke into the bunker is of itself an exceedingly interesting and somewhat intricate construction, and the general formation of same is shown in *Fig.* 1. It will be noticed that the whole of this internal structure is carried on the subsidiary independent beams, H, which are, again, supported by the main cantilever girders, A.

For greater rigidity the reinforcement of the internal columns, K, has been carried up in continuous lengths, from the beams, H, to the summit of the arched stays, N.

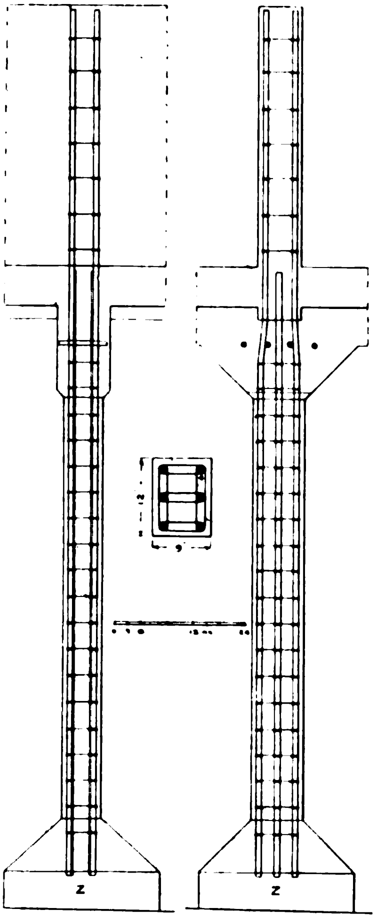


Fig. 7. Columns Y1 to Y4.

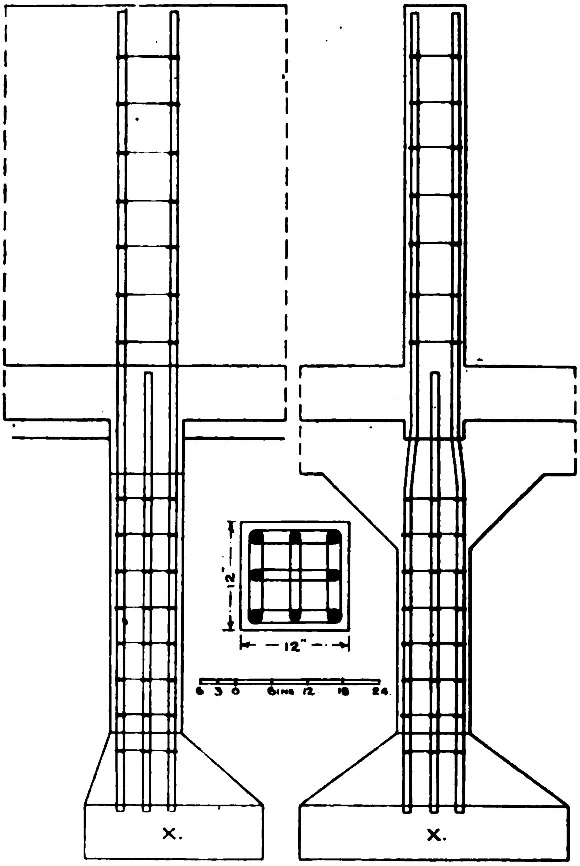
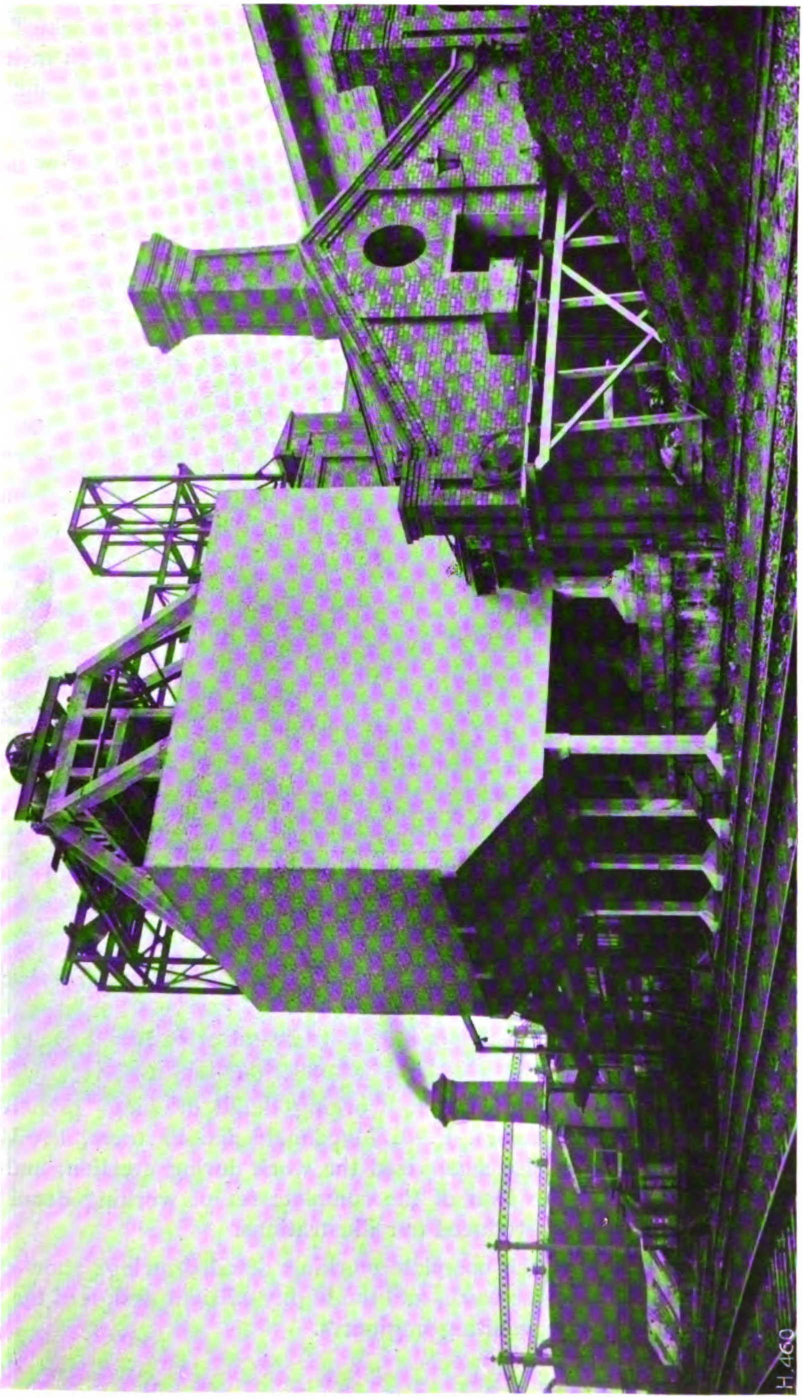


Fig. 8. Detail of Columns Y5.

These columns are strongly braced together by means of the diagonal bracings, L, and the horizontal struts, R, and are also held at the summit by the tie beams, T, V, and W, which also serve to support the receiving hopper at summit.

The diagonal bracings, L, also serve to receive the inclined slabs, S, and for this purpose are constructed with a projecting fillet for part of their length,

REINFORCED CONCRETE COKE BUNKER



Reinforced Concrete Coke Bunker at Dunfermline.

the formation being as shown in the detail thereof, and the coke flows down this series of inclined slabs in such manner that it is not broken in its descent, and finally spreads out to its natural angle of repose in the main storage bunker.

The general arrangement of the bunker was carried out to the instructions of Mr. Alexander Waddell, manager of Dunfermline Gas Works.

The contractors for the reinforced concrete work were Messrs. John Ellis & Sons, Ltd., and the steel reinforcement was supplied by The Trussed Concrete Steel Co., Ltd.

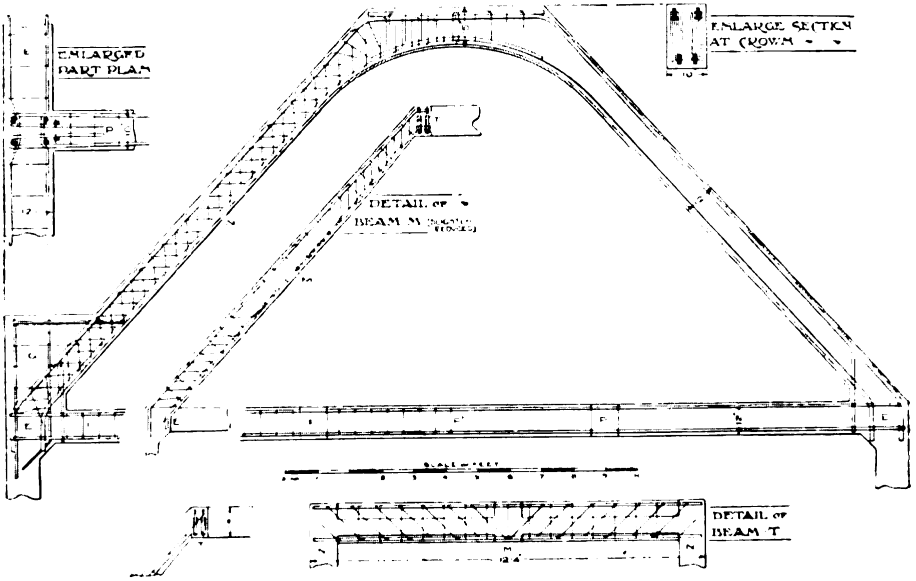
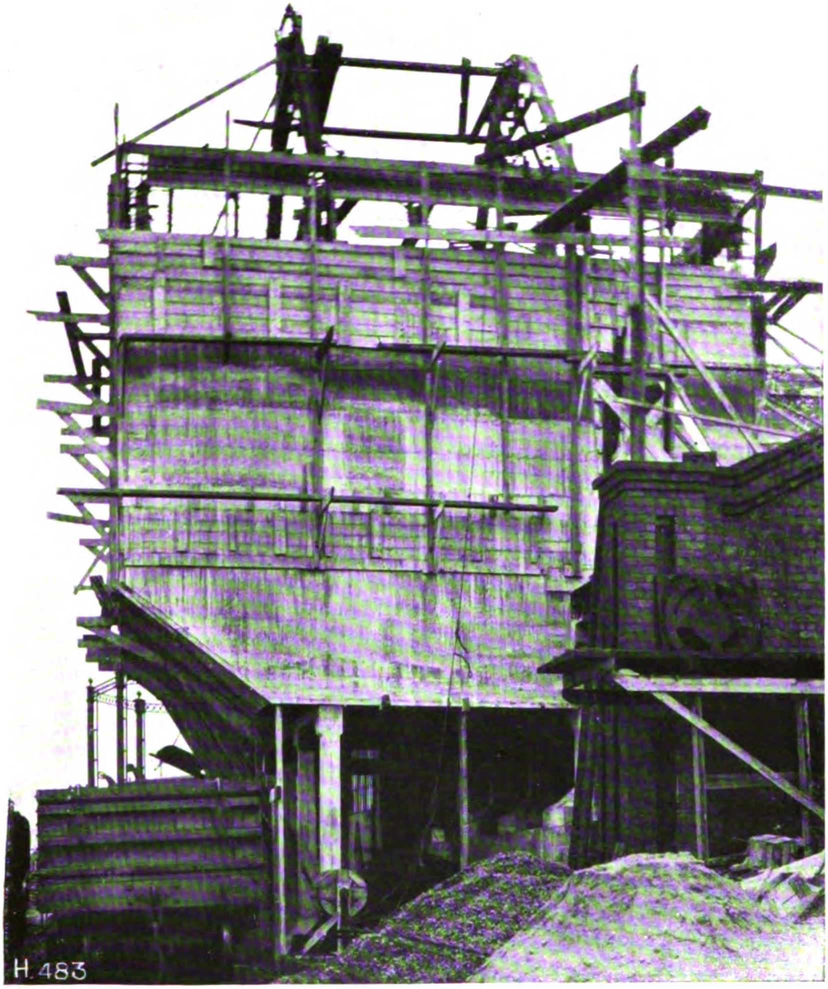


FIG. 9. DETAIL OF ARCHED STAYS.

The cement used was the J. B. White brand of Portland cement and was supplied by The Associated Portland Cement Manufacturers (1900), Ltd.

The work was carried out to working detail drawings prepared by the consulting engineers, Messrs. F. A. Macdonald and Partners, 135 Wellington Street, Glasgow, who also supervised the work during erection, and to whom we are indebted for the loan of the complete set of working detail drawings from which we have reproduced our illustrations.

We may add that the complete working detail drawings show clearly the intricacy of this particular work, and the highly efficient design of the reinforcement adopted by the consulting engineers.



View in course of construction.

Reinforced Concrete Coke Bunker at Dunfermline.

THE CALCULATION OF CONTINUOUS BOWSTRING GIRDERS, AND ITS APPLICATION TO A REINFORCED CONCRETE VIADUCT.

The present article is a translation of a pamphlet written by Mr. H. Lossier, and deals with the case of a continuous bowstring viaduct designed by Messrs. Considère, Pelnard & Lossier, and which has been adopted by the Orleans Railway. Messrs. Considère have kindly placed the information at our disposal.—ED.

ALTHOUGH the computation of continuous beams has now become a common practice, the treatment of continuous arched structures has, owing to the complexity of the theory involved, remained almost untouched. This type of structure, however, assumes importance in large constructions, as it permits an economical distribution of the material and a large margin of safety.

The author has shown, in previous publications, that continuous arched structures may be computed in a simple manner by means of the ellipse of elasticity. The present case is that of a continuous bowstring viaduct, without diagonals, the design of which, by Messrs. Considère, Pelnard & Lossier, has just been adopted by the Orleans Railway for Contras (Gironde), as the result of a competition.

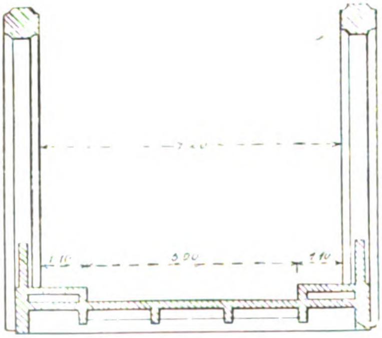


FIG. 1. SECTION OF VIADUCT.

The viaduct consists, as shown in *Figs.* 1 and 2, of a platform 7·2 metres (23 ft. 7 in.) wide between the parapets, carried by two main girders of five spans, namely, a central span of 40 m. (131 ft.), two intermediate spans, each of 31 m. (101 ft. 6 in.), and two terminal spans, each of 9 m. (30 ft. 6 in.), giving a total length of 120 m. (395 ft.). Each girder in the central spans is composed of an upper parabolic member and a straight lower member, united by vertical members, whilst the terminal spans are simply prolongations of the lower member.

Considered in itself, each of the central spans is a bowstring without diagonals. In this structure, the vertical members, being hinged at the ends, only transmit vertical stresses, and cannot be considered as replacing the diagonals. We may assume without serious error that corresponding points on the upper and lower members are equally displaced vertically, and therefore jointly resist the bending stresses. Each girder may be regarded as a continuous arched structure of three spans, the two ends being each prolonged by a horizontal beam, freely supported at the end, without breach of continuity (*Fig.* 3). The computation of such a system is greatly simplified by the employment of the graphical method, due in the first place to Prof. W. Ritter, and based on the theory of the ellipse of elasticity. (See H. Lossier, "General Theory of the Continuous Elastic Arch on Rigid Supports," Paris, 1903).

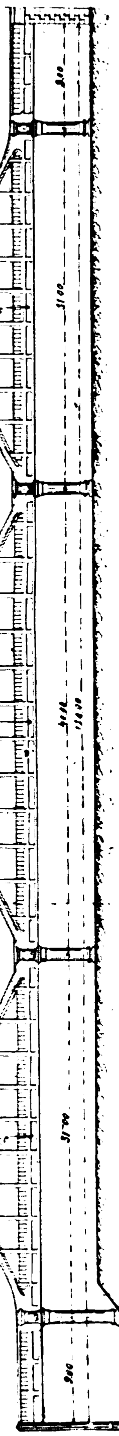


Fig. 2. Elevation of Viaduct.

The ellipse of elasticity of the point B (*Fig.* 4) is determined by taking into account the fact that the plane *bb* cannot undergo a movement of translation, and that the centre of rotation coincides with B. The "elastic weight" of the ellipse, G_B, is found by assuming that the beam AB is fixed at B and free at A, and that the elastic weight of its ellipse is G_1. If a vertical force P acts at the free end A the vertical displacement at A is

$$\Delta h = PG_1 \frac{l_1}{2} n$$

where l_1 is the length of AB and *n* the distance from A to the antipole N of the force P relatively to G_1. The angle through which AB must be turned to annul this displacement is $\alpha = \frac{'}{l_1}$

$$\text{Now,} \qquad \alpha = \frac{\Delta h}{l_1} = Pl_1 G_B$$

$$\text{or,} \qquad G_B = G_1 \frac{n}{2l_1}$$

In order to determine G_B graphically, a vertical is drawn proportioned to G_1, at a distance l_1 from B_1 and a vertical dropped from N gives the value required.

For similar reasons, the ellipse of elasticity at C is reduced to a point coinciding with C. Assuming the system ABC to be free, we find the ellipse of elasticity G'_2 of the point C. The elastic weight G_C is found by a construction similar to that previously adopted. As C is fixed, the ellipses G'_2 and G_C must lead to the same value for the rotation of C_1, or

$$Rr'_2 G'_2 = Rr_C G_C$$

r'_2 and r_C being the respective distances of G'_2 and G_C from the straight line *kk*. Then

$$G_C = G'_2 \frac{r'_2}{r_C}$$

The ellipses at the points D and E are determined in a similar manner. The structure being symmetrical, it is unnecessary to perform a series of operations in the reverse direction, starting from F.

In each span, two classes of stresses have to be considered, (1) those due to loads acting directly on the span in question, and (2) those due to loads acting on other spans and transmitted by the adjoining spans.

(1) The three middle spans may be regarded as simple arches fixed at the extremities on elastic supports. Such an arch may also be regarded as a simple arch with fixed extremities on fixed supports, infinitely small elastic elements intervening, the deformations of which coincide with the movements of the supports. These fictitious elements have as ellipses of elasticity those of the supports themselves. The middle spans, therefore, have the following ellipses of fixing:

Span BC—At B, ellipse G_B; and at C, ellipse G'_C.
,, CD— ,, C, ,, G_C; ,, D, ,, G'_D.
,, DE— ,, D, ,, G_D; ,, E, ,, G'_E.

Combining the ellipses of elasticity of the different elements of each span by the method of funicular polygons, taking into account the supports, we obtain the surfaces of influence of the components of the reactions at the junctions. These surfaces enable us to determine, as shown in *Fig.* 3, the lines of intersection and the envelopes of the reactions, as for arches of the ordinary type. The central arch, treated in this way, is symmetrical, whilst the two adjoining arches are asymmetrical, and have been so treated.

(2) Any force R_1, acting on the extremity C of a system ABC, through the intermediary of the adjacent span CD (*Fig.* 3), is balanced by two reactions: the reaction V_1 of the support and reaction H_1 of the system ABC. These reactions must satisfy certain conditions which enable them to be determined without ambiguity. The support of C being hinged, the reaction V_1 must pass through the point C, which must also coincide with the centre of rotation relative to the reaction H_1. For this condition to be realised, H_1 must act along the antipolar *kk*, and the resolution of R_1 into V_1 and H_1 is thus completely determined. The action of H_1 on the span AB is determined by the fact that the reaction at A is vertical, owing to the expansion device, whilst that at B passes through the hinge.

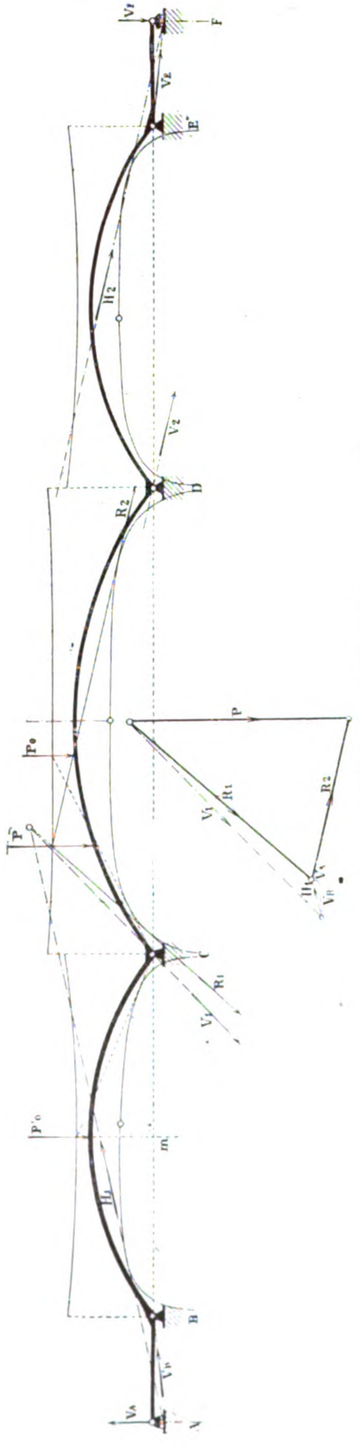


Fig. 3. Envelopes of Reactions.

Imagine, in *Fig.* 3, a force P acting on the central span CD; this force may be resolved into two others, R_1 and R_2, tangential to the envelope and cutting the line of action of the force P on the line of intersection of the reactions of the span CD. Each of these forces R_1 and R_2 may then be resolved into two forces H_{1-2} and V_{1-2}, the one acting on the adjacent span, the other on the hinge of the adjoining support. Each force H_{1-2} may be again resolved into a vertical reaction at the end supports, and an oblique reaction passing through the hinge B or E.

Should the force P have the position P_o, so that the reaction V_1 passes through the hinge C, the thrust H_1 is zero, and the action of P_o on the system ABC is zero, consequently all the lines of influence of the moments of flexion of sections of this system will cut the axis of abscissæ at the ordinate of the force P_o.

The author has also determined graphically the surfaces of influence of the bending moments of different sections of the central span CD, and also the most unfavourable positions of loads, as regards the bending moments. Whilst, in ordinary continuous beams, the most unfavourable loads generally affect whole spans separated by spans free from load, in the system considered the three middle spans are always loaded, but only over a portion of their length. The terminal spans, on the other hand, are to be regarded as ordinary beams, and are therefore either completely free or completely loaded.

The construction of a further diagram of the maximum bending moments under the most unfavourable distribution of loads leads to the conclusion that, by assuming for the whole span the value of the maximum moment, treating the span as hinged at the junctions, stresses are arrived at which are too high at the crown, but too low at the springing of the arch. High values, and consequently satisfactory as regards strength, if not as regards economy, are therefore obtained by assuming no fixing at the junctions for sections at the crown and ribs, and perfect fixing for sections near the springing. This conclusion must not be made a general one, for if the spans be very unequal, the shorter ones may be subjected to stresses largely in excess of those so calculated.

A further graphical construction permits the calculation of the load required to produce a given vertical displacement of a support. It is found that, in order to reach

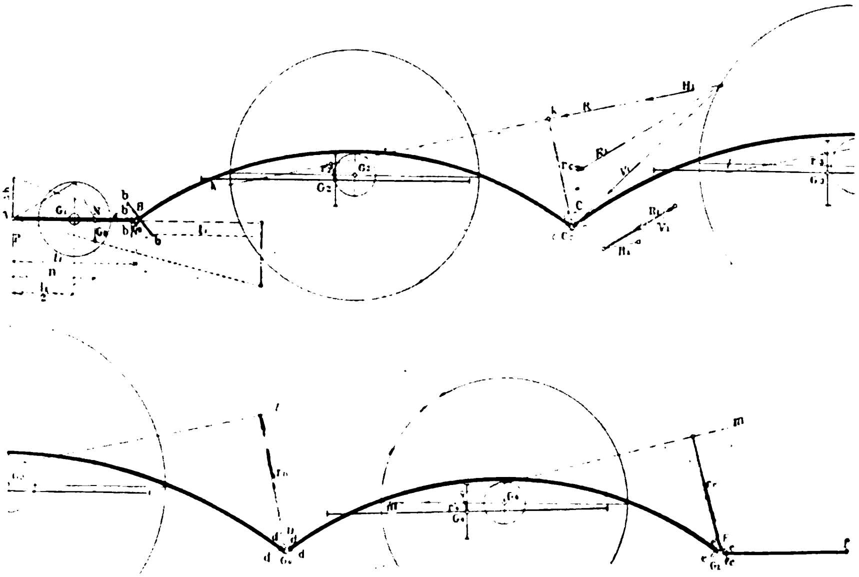


FIG. 4. CONSTRUCTION FOR FINDING ELLIPSES OF ELASTICITY.

the elastic limit of the steel reinforcement, a vertical displacement of no less than 20 cm. (8 in.) would be required. This is unlikely to be attained. The type of construction illustrated in this viaduct provides a degree of flexibility which is considerably in excess of that of most other systems.

It now remains to be shown that the discrepancies between the theoretical values and those actually realised are not greater than in the more usual types of structure. The two hypotheses requiring examination are: (1) that the linear variations of the inferior members and of the vertical connecting members are negligible; (2) that the superior and inferior members satisfy the theory of elastic deformations.

So far as the lower members are concerned, the combined action of the dead load and of the surcharge producing the maximum bending moment in the central span, produces an elongation of 0·3 millimetres per metre. Taking the tension of the concrete into account, it is found that the actual stresses produced (tension in the lower and compression in the upper members) are about 13 per cent. of the total calculated stresses. A similar calculation shows that the elongation of the vertical members, also taken as being 0·3 millimetres per metre, produces stresses which are less than 2 per cent. of the total stresses. Together, it may be said that the elongation of the lower horizontal and vertical members increases the calculated stresses by 15 per cent. The secondary stresses in steel constructions, due to the rigidity of the junctions, have a similar value, and it is therefore legitimate to neglect the influence of such elongations in continuous bowstring girders, as is done in dealing with steel structures.

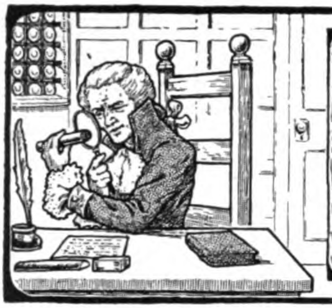
The superior members are subject to complex bending and resist only compressive stresses. They consequently behave as arches, the deformations of which correspond, within the permissible limits, with the theory of elasticity, as was proved by the experiments of the Austrian engineers in 1895.

Experiments by the French Reinforced Concrete Commission have proved that, as soon as the elongation of concrete exceeds by 0·1 to 0·2 mm. per metre that which it could resist without rupture if it were not reinforced, its co-efficient of elasticity diminishes rapidly and soon becomes practically zero. Now, the concrete of the inferior members is subjected to an initial elongation of about 0·3 mm. per metre produced by the dead and live load; this concrete therefore behaves in some respects as a plastic substance under the bending stresses acting on the horizontal members. Under such conditions, practically the whole effective moment of inertia of the members is furnished by the steel reinforcement, the percentage of which is relatively high. The theory of elasticity is therefore applicable to them. It follows that the exactness with which a structure of this kind can be computed is similar to that of other reinforced concrete constructions. The application of the theory of elasticity, which was experimentally justified for arches by the investigations of the Austrian engineers in 1895, and for continuous beams, suitably reinforced, by those of Messrs. Wayss & Freytag, appears to be equally admissible in the case here considered.

Conclusions.—It is not possible to draw conclusions of a general nature from the study of this particular case. The only object of this paper is to show the remarkable simplicity with which the ellipse of elasticity permits the solution of apparently very complex hyperstatic systems.

In spite of the incontestable advantages of the so-called exact methods of computation, it would be an exaggeration to condemn *a priori* all the simplified methods which lead to a less rational distribution of the general stresses. In fact, in an isostatic structure, the stress in any member is independent of its stiffness and of its resistance; should the latter be insufficient, rupture occurs, whatever may be the strength of the other portions of the structure. In a hyperstatic structure, on the other hand, the distribution of the general stresses is determined by the deformations of the different elements. If one of these begins to yield from lack of resistance, the load, or a part of it, is taken by the stronger members, and if the latter can resist the additional stresses thus produced, rupture may be avoided. This is what occurs in reinforced concrete beams, the continuity of which is imperfect over the supports, and the stability of which is nevertheless assured by the resistance of the other parts.

However, such a redistribution of stresses cannot occur, in general, without the structure suffering injuries which more or less affect its good appearance and its durability. The so-called exact methods of computation will therefore always have the advantage, in comparison with the approximate methods, of leading to a more rational disposition of material, and of allowing the strength of each member to be better proportioned to the stresses it is to support.



TESTS ON REINFORCED CONCRETE CONDUCTED IN GREAT BRITAIN.

(PART VII.)

The first six articles of this series appeared in our May, September, November, January, February and March numbers respectively. The following particulars of tests are now presented, and further articles will appear from time to time.—ED.

A SPIRAL COLUMN.

Mr. William Dunn, F.R.I.B.A., with the co-operation of Messrs. W. Cubitt & Co., has made and tested two hooped columns such as recommended by M. Considère.

The columns were of octagonal section of the dimensions shown (*Fig.* 38), and 10 ft. in height.

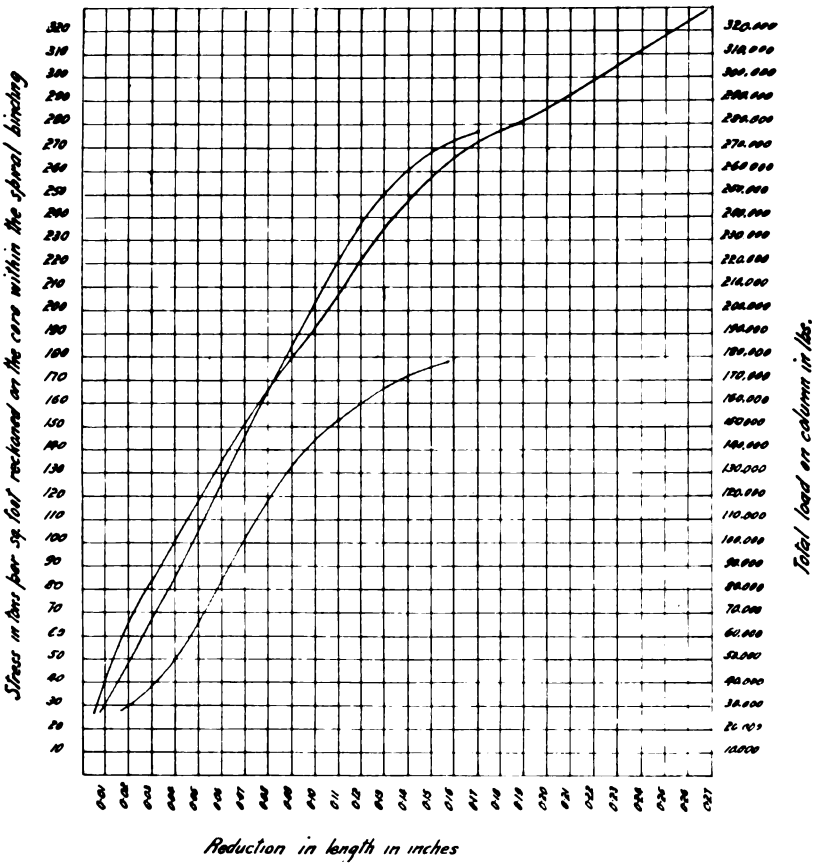


FIG. 37. DIAGRAM SHOWING GRADUAL SHORTENING OF THE COLUMNS UNDER INCREASED LOAD.

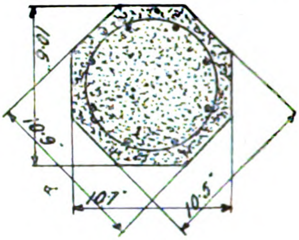


Fig. 38.

The reinforcement of the first column tested consisted of eight vertical wires $\frac{1}{4}$ in. diameter extending for the full height of the column. These were bound round spirally with $\frac{1}{8}$-in. wire, the length of the wire employed for the spiral being 227 ft. The volume of longitudinals was therefore 0·42 per cent. and that of the spirals 0·30 per cent. of the total volume of the concrete. The wire was first wound closely round a drum, and was then allowed to spring out to the exact pitch of 1¼ in., being $\frac{1}{7 \cdot 6}$ of the diameter of the spiral (M. Considère recommends one-seventh to one-tenth), the wireworker having no difficulty in arranging this. Both sets of wire were of mild steel, and the verticals and spirals were bound together with fine wire at the crossings to keep them in position while the column was moulded. The diameter of the spiral was 9½ in. The moulding was done vertically, in 6-in. layers, and rammed with a wooden rammer 8 in. in diameter.

The concrete was mixed in the proportions of 1 of Portland cement to 2 of Leighton Buzzard sand, and 2½ of pea shingle, or about 970 lb. of Portland cement to ·083 cu. yd. of sand and 1 cu. yd. of shingle.

The column was kept in the mould for five days, and was then removed and stored in wet sawdust for a further period of 56 days. It was then tested horizontally in a machine by Messrs. Kirkaldy, an endeavour being made to counteract the effect of the bending due to its own weight by a weight equal to half the weight of the column, acting upwards at the centre. The second column was made and tested at a later date and in the same manner. In this case, however, while the dimensions of the column were kept the same, the sizes of the reinforcements were increased, the spirals being 0·21 in. and the longitudinals $\frac{1}{2}$ in. diameter. The spacing of the spirals was again 1¼ in. The volume of the longitudinals was 1·00 per cent., and that of the spirals 0·65 per cent., of the total volume of the column. When the column was tested the portion of the former column which had failed was cut away and the shortened column re-tested.

The gradual shortening of the columns under an increasing load is shown in the diagram (*Fig.* 37), the several columns being marked A, B, and C, the latter being A as re-tested, the stresses being those per square foot of section within the spiral windings. The portion outside, not being reinforced, does not add materially to the resistance, and is only necessary as a protective coating. This diagram shows that for Column A, as in the case of M. Considère's tests, there is a great shortening at first under light load due to the particles taking a permanent set amongst themselves and to the concrete taking up its bearing against the spirals. The proportion of the volumes of the reinforcements with respect to the *total* volume of the concrete was 0·0042 and 0·01 for the longitudinals, and 0·0030 and 0·0065 for the spiral in Columns A or C and Column B respectively.

At about 780 lb. per sq. in. on Column A the shortenings became

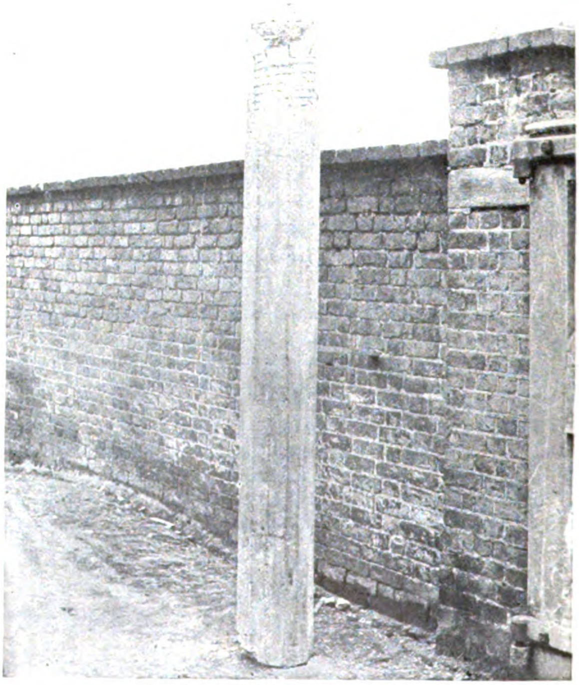


Fig. 39. Column A.

regular—*i.e.*, the stress and strain were proportionate. This continued up to about 2,020 lb. per sq. in., when the outer casing of the concrete outside the spirals began to crack. (It will be noticed that this is about the resistance under direct compression for concrete not reinforced.) The shortening then increased more rapidly than the load. When failure occurred, at 2,815 lb. per sq. in., it was local and near one end where the outer casing flaked off (vide, *Figs*. 39 and 40). The spiral wire broke in two places, showing the characteristic reduction of area at the point of fracture, and the longitudinal wires bulged outwards at the point of fracture. The concrete at this place proved exceedingly friable, and easily rubbed off with the fingers. The sand seemed to be not as sharp as required in the best concrete work.

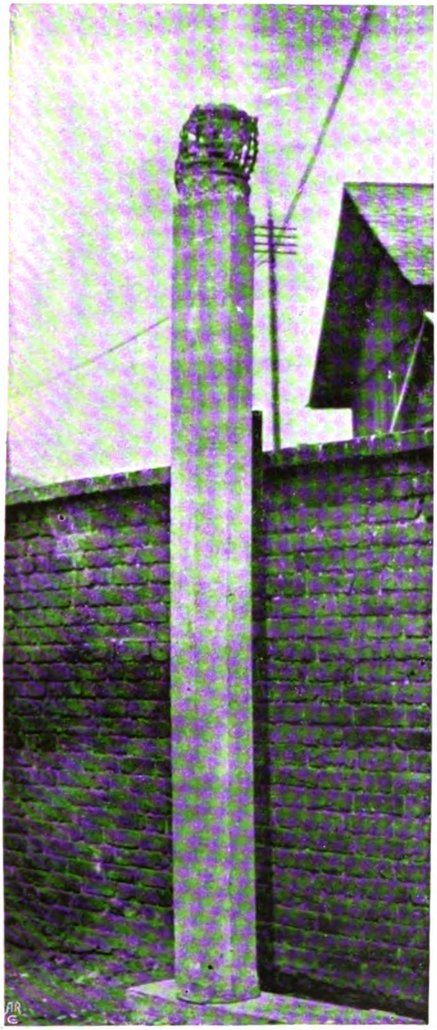
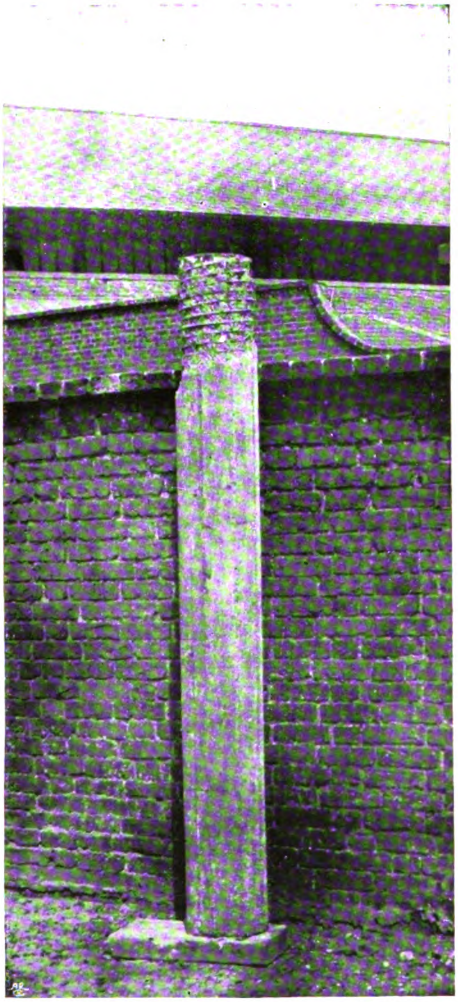


FIG. 40. COLUMN B.



COLUMN A (RE-TESTED).

The failures of these columns were gradual, and even after the failure the two portions of the first column were sufficiently held together by the eight longitudinal wires to permit of the column being slung out of the machine as one piece by means of a rope sling round its centre. *Figs*. 39 and 40 show views of the columns after failure. The columns were made by men having no special experience in reinforced concrete construction, and under no specially skilled supervision.

BEAMS BY MESSRS. W. CUBITT & CO.

Some small test beams were made by Messrs. W. Cubitt & Co., and tested in their Amsler vertica press by Professor Unwin for the Royal Institute of British Architects' Joint Committee on Reinforced Concrete. The dimensions and arrangement of reinforcements are shown in *Fig.* 41.

TABLE I.

Mark on Beam	Maximum Load	Load at which the last deflection was taken	Ultimate Deflection	Deflection with 5 Tons Load	Set with 6 Tons Load	At First Crack		Nature of First Crack
						Load	Deflection	
	Tons	Tons	In.	In.	In.	Tons	In.	
A[1]	6·20	6·00	0·090	0·060	—	3·5	0·037	Diagonal cracks left of centre.
A[2]	5·80	5·00	0·040	0·040	—	4·5	0·035	Diagonal cracks right of centre.
A[3]	5·80	5·50	0·060	0·050	—	5·0	0·042	Diagonal cracks left of centre.
B[1]	9·50	8·00	0·063	0·029	0·005	8·0	0·063	Cracks, chiefly diagonal.
B[2]	10·00	9·00	0·100	0·040	0·008	7·0	0·060	Diagonal crack right of centre.
B[3]	9·20	9·20	0·488	0·068	—	8·5	0·126	Diagonal cracks near ends and after at centre.
C[1]	9·60	9·50	0·150	0·040	0·010	8·5	0·089	Diagonal cracks.
C[2]	8·50	8·00	0·085	0·042	0·002	5·0	0·042	Very small cracks left of centre.
C[3]	9·50	9·50	0·060	0·054	—	7·0	0·078	Cracks near ends.
D[1]	6·90	6·50	0·080	0·044	0·020	3·0	0·026	Small cracks left of centre.
D[2]	6·90	6·90	0·460	0·058	—	5·5	0·056	Two, nearly vertical.
D[3]	7·30	7·10	0·660	0·058	0·030	5·5	0·060	Nearly vertical.

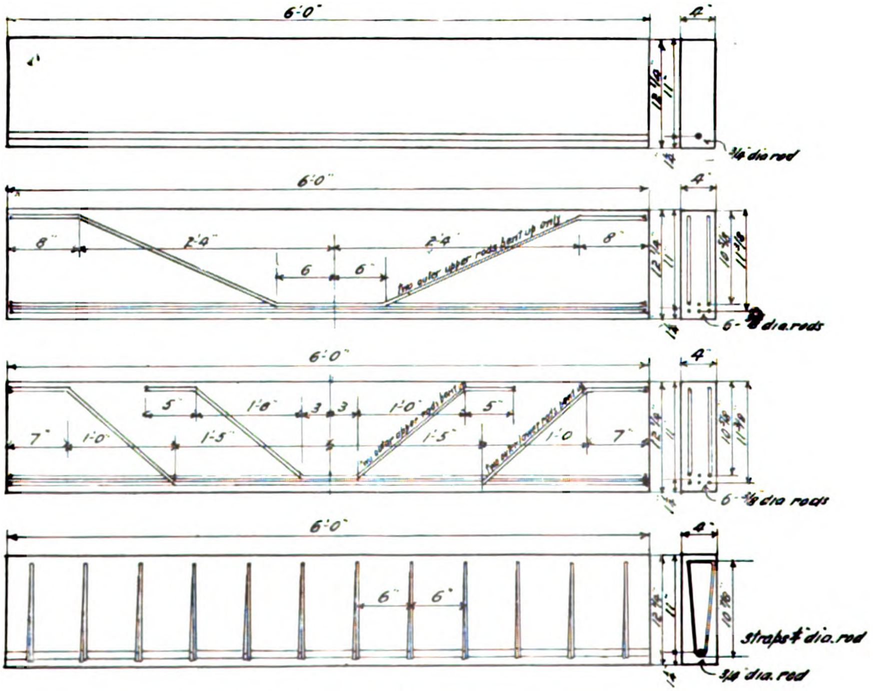
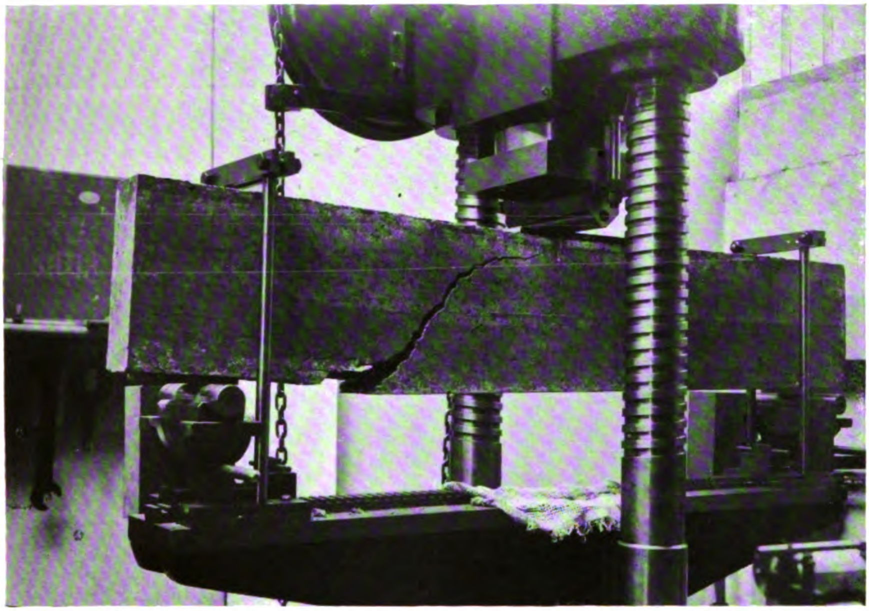


FIG. 41. DIMENSIONS AND ARRANGEMENT OF REINFORCEMENTS.

Table I. gives the results of the tests. The loading had been continued considerably beyond the time of failure before the photographs were taken, yet none of the beams showed any signs of collapsing. Shearing had a considerable effect in the failure of all the beams. Beam A failed (as would be expected) entirely from diagonal tension, the shearing along the rods being clearly shown

Fig. 42. Beam A¹.



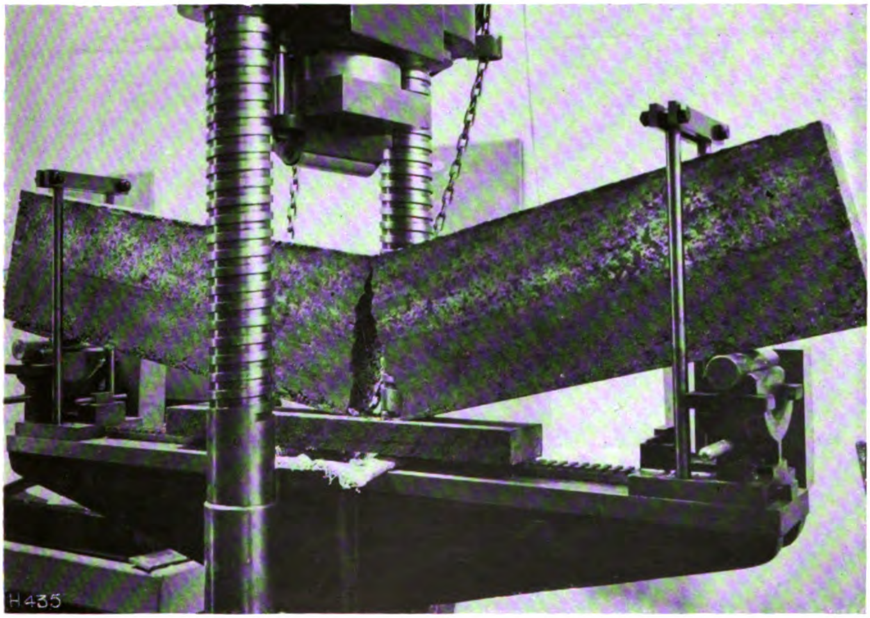
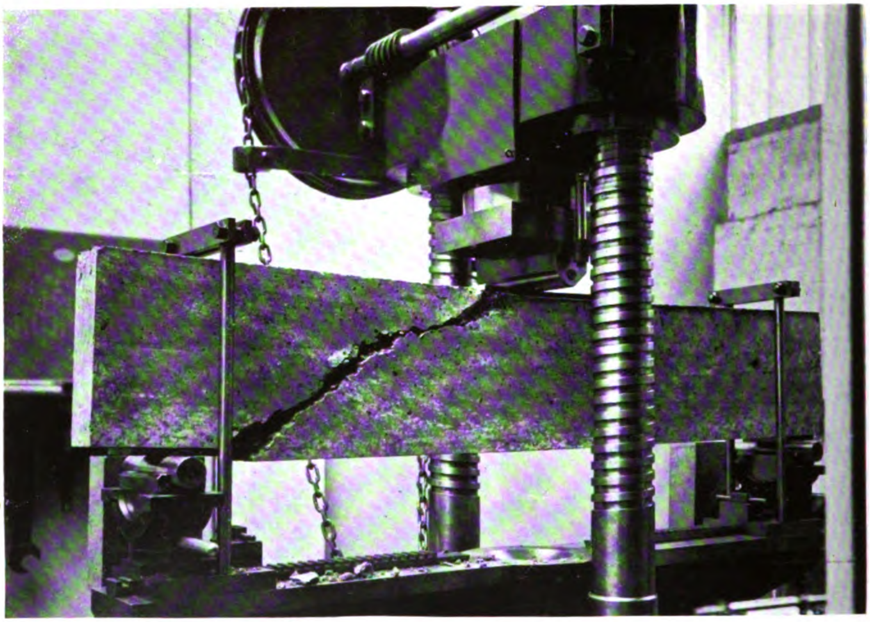


Fig. 43. Beam "A" type, plain concrete.
Beams Tested for the R.I.B.A.'s Joint Committee on Reinforced Concrete.

in the photograph. The effect of diagonal tension is also very evident in Beam B^2, and the influence of shearing stresses is indicated by the inclination of the crack in Beam C^3. The crushing at the top of this beam did not occur until the bottom crack had opened considerably. The vertical crack in Beam D^3 opened at one of the stirrups, and a wedge-shape piece dropped out at the bottom; both

Fig. **44.** Beam B^1.



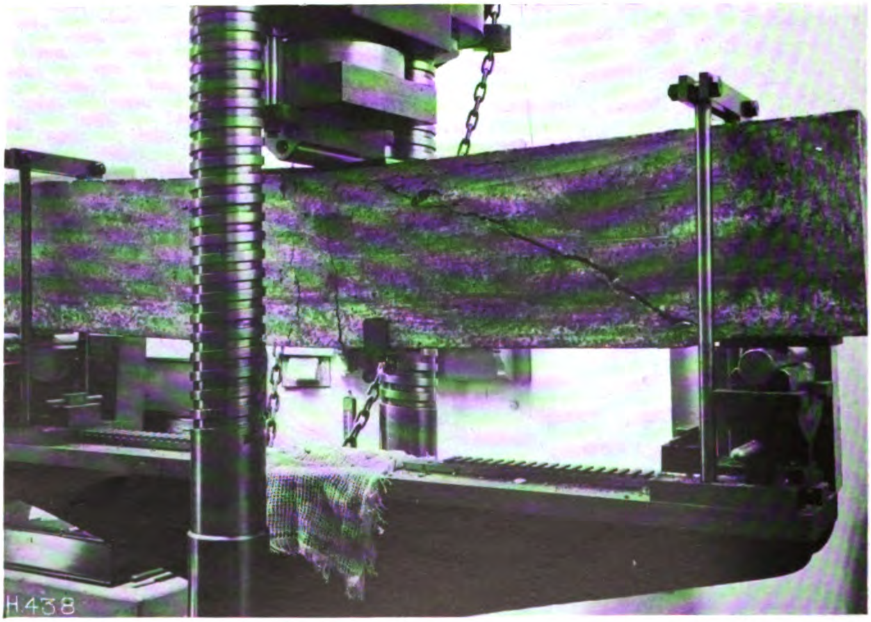
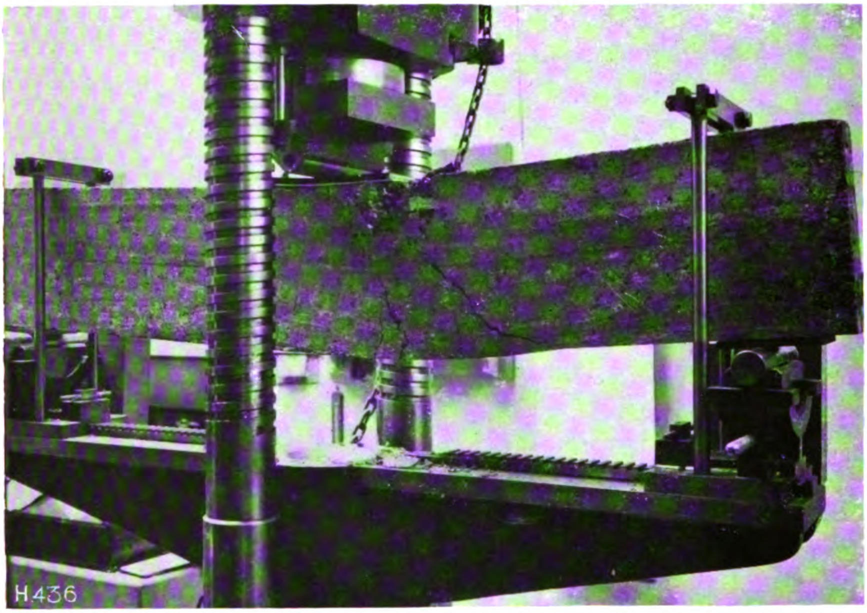


Fig. 45. Beam B^3.

Beams Tested for the R.I.B.A.'s Joint Committee on Reinforced Concrete.

the vertical and inclined cracks in this beam opened simultaneously. In the tests of which these beams are samples, three beams of each class were tested.

Fig. 46. Beam C^1.



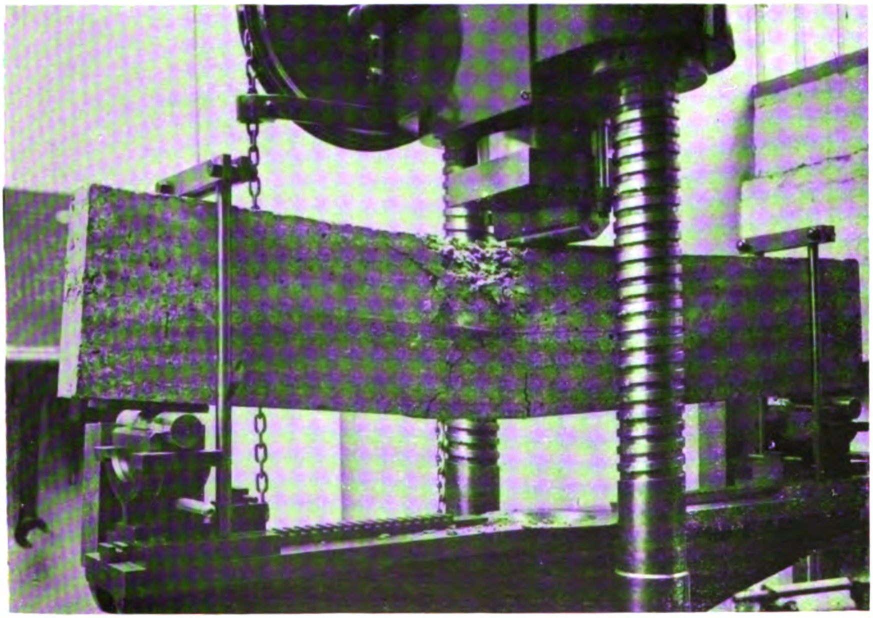
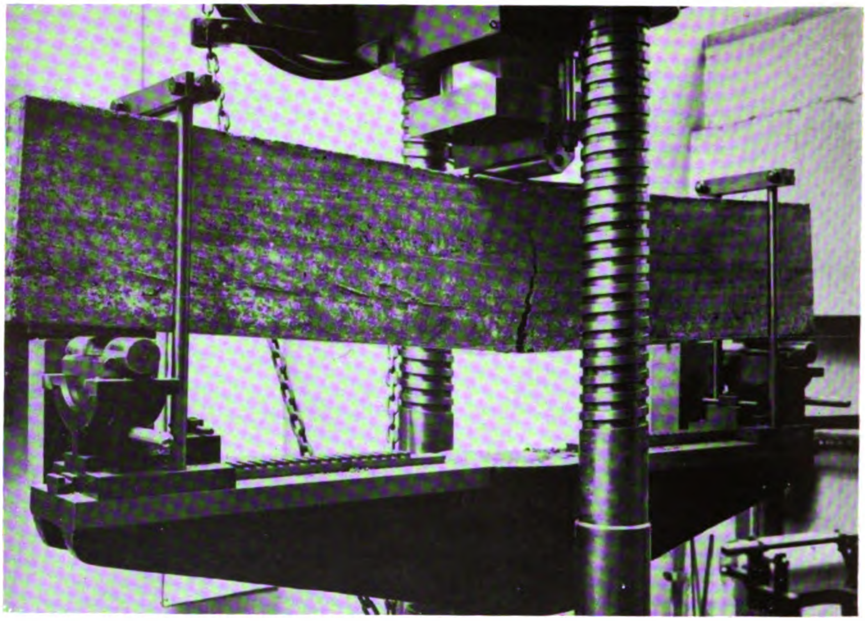


Fig. 47. Beam C^2.

Beams Tested for the R.I.B.A.'s Joint Committee on Reinforced Concrete.

Fig. 48 Beam D^1.



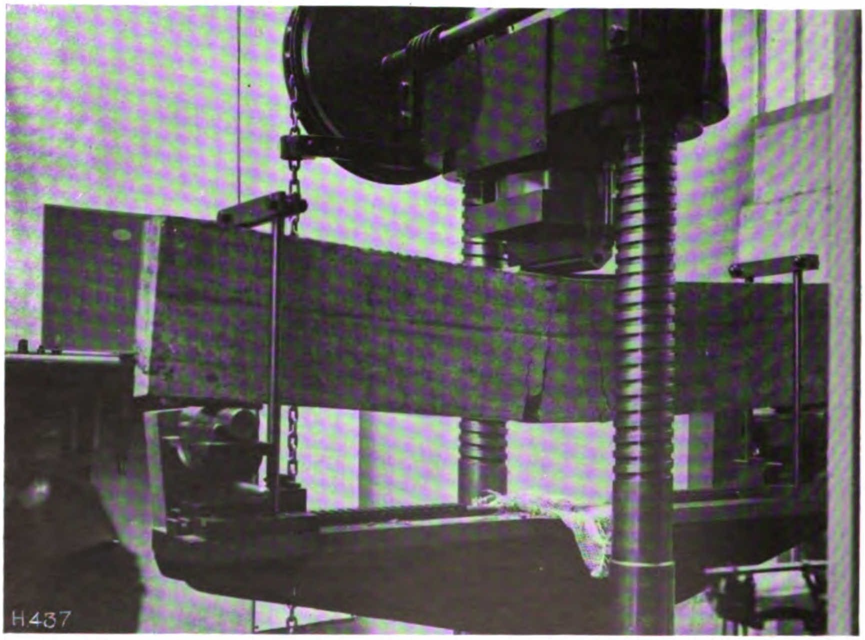


Fig. 49. Beam D^2.

BEAMS TESTED FOR THE R.I.B.A.'s JOINT COMMITTEE ON REINFORCED CONCRETE.

(*To be continued.*)

THE NEW MONEY ORDER OFFICES AT HOLLOWAY.

We are again giving particulars of a Post Office Building erected in reinforced concrete under the supervision of H.M. Office of Works, the present example being the structure intended for the use of the Money Order Department at Holloway. We are now giving a preliminary article on the building in its early stages and will later on publish one on the completed structure.—ED.

THE building described in this article, and which is now in course of erection, is the latest of a series of large buildings for the extension of Post Office facilities in London.

This work is being erected under the instructions of H.M. Office of Works, for which Sir Henry Tanner, I.S.O., F.R.I.B.A., acts as the principal architect.

The entire construction, with the exception of the front wall elevation, is in reinforced concrete on the Coignet system and under the supervision of Mr. J. Rutherford, of H.M. Office of Works. The contractors for the work are Messrs. W. King & Son, of London, who have also executed the Western District Post Office and the Lombard Street Branch Post Office on the same system.

The contract for this building was placed in open competition, and, after consideration of the tenders and a very careful expert examination of the various schemes proposed, the Office of Works decided to accept the one submitted by Messrs. Edmond Coignet, Ltd.

The building is in the shape of an E. The total length of the front measures approximately 253 ft. and the width of the main body is about 50 ft. The three wings measure respectively: 88 ft. by 42 ft., 101 ft. by 42 ft. and 76 ft. by 42 ft.

The building is to be composed of a basement, five reinforced concrete floors, and a flat roof of the same material. The total height of the structure from the ground level to the roof will be approximately 85 ft. There will also be a certain number of mezzanine floors throughout the height of the main body. Although the front elevation is to be executed in brick and stone, the walls of the wings are to be in reinforced concrete, of a thickness of 5 in. only.

The stairs and balconies of the building are to be entirely in reinforced concrete. The building is to be fitted with ventilating shafts, also of the same material.

On the ground, situated at the back, a large boiler-house, entirely in

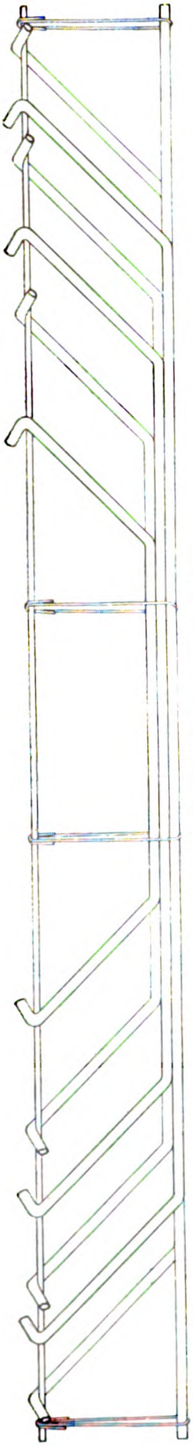


Diagram of Reinforcement of Beams.

reinforced concrete, is also to be erected, the dimensions of which are approximately 47 ft. in length, 36 ft. in width and 26 ft. in height. This building will be partly buried in the ground.

An underground passage in reinforced concrete will provide means of communication between the various wings of the building and the boiler-house. A water tank will also be erected close to the boiler-house.

The contractors began the work on the 25th of October last, and we are presenting two photographs, taken recently, showing the progress of the work.

The centering for the pillars, floors and walls underneath the first floor, which is now completed, is shown in the frontispiece to this issue. On page 264 we give a back view of the building, showing two of the wings, taken from the site of the boiler-house excavations.

It is expected that the entire building will be finished in about fifteen months from the date of the beginning of same.

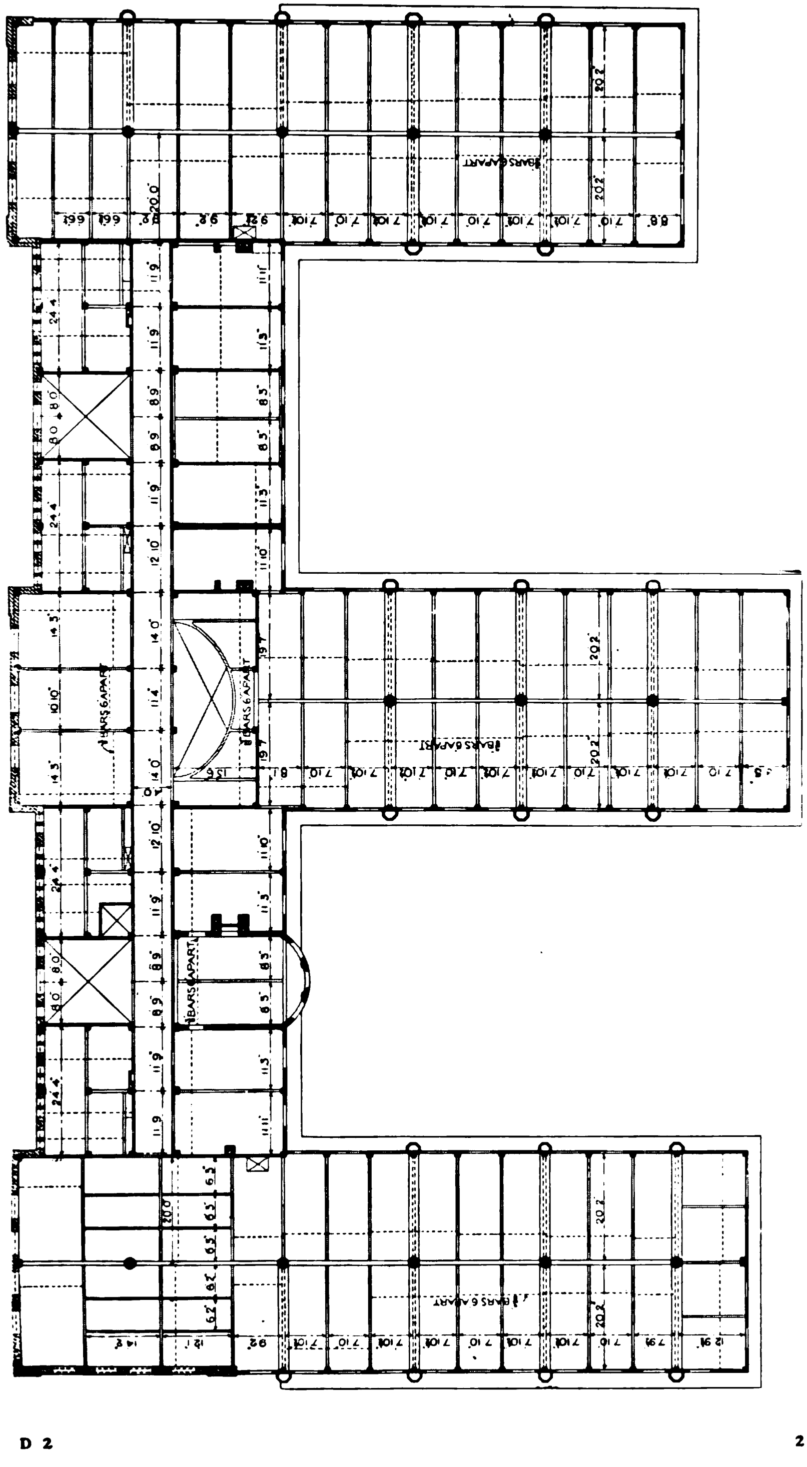
On page 263 we give a reproduction of a plan of one of the floors, showing the general arrangement of the beams and pillars. We may state that the particular method of reinforcement for the beams is that known under the name of "Coignet system of reinforcement of equal resistance." On this page we show a diagram, and it will be noticed that this method presents the advantages of the most economical sections of steel and concrete in any section of the beam, the section of the steel in tension being greater in the middle portion of the beam and gradually growing less towards the points of support, in proportion to the bending moments. The ends of the bars are made use of to resist the shearing stresses by being bent upwards and hooked over a top bar. The shear members are also spaced gradually closer together at each point of support. As shown in the sketch they are all bent at an angle of 45°.

The reinforcement of the pillars consists of a certain number of longitudinal principal bars, bound by a spiral bar of small diameter.

The slabs are composed of a meshwork of principal bars and distributing rods.

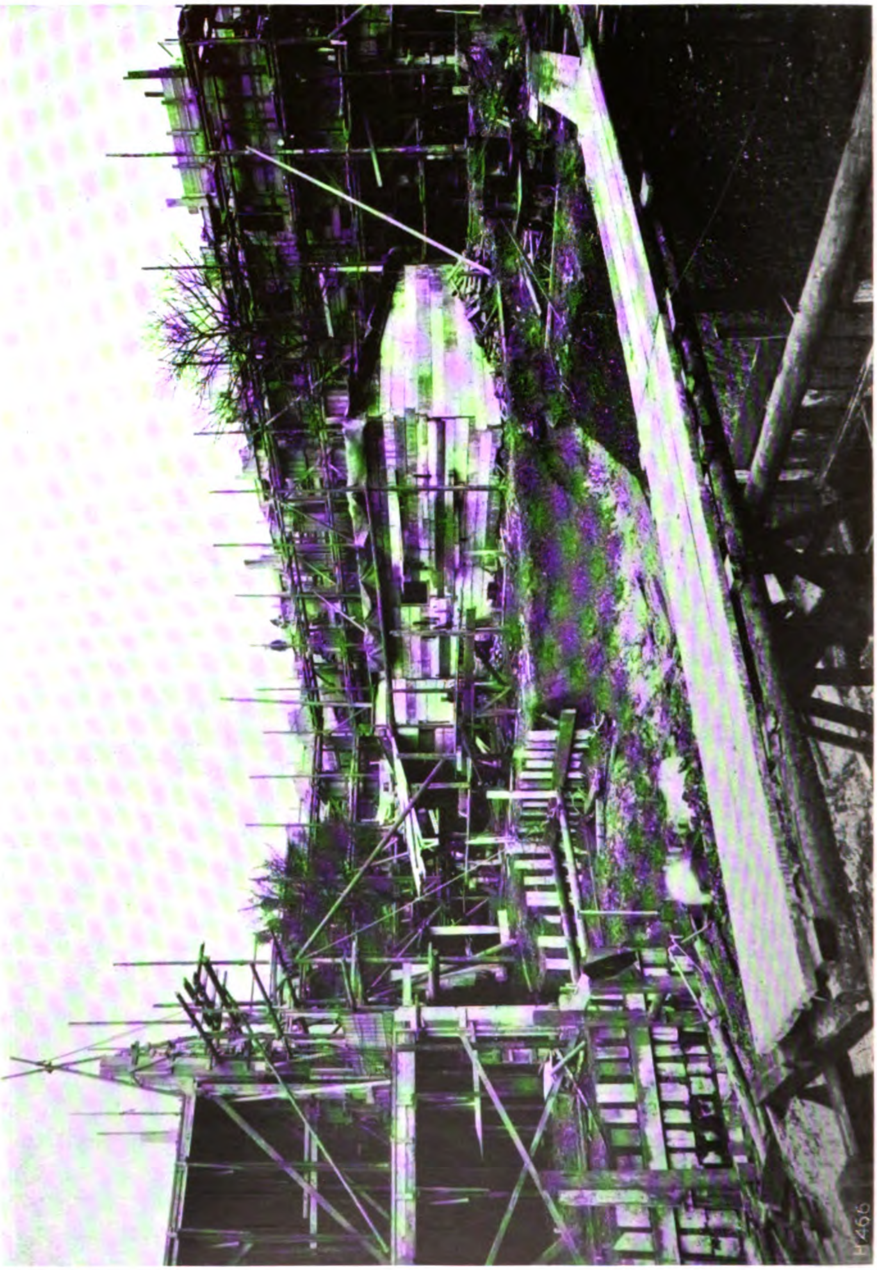
The cement being used in this work is the "Ferrocrete" brand, manufactured by the Associated Portland Cement Manufacturers (1900) Ltd.

It may be interesting to mention that this is the third Post Office building which has been erected on the Coignet system of reinforced concrete for the Office of Works.

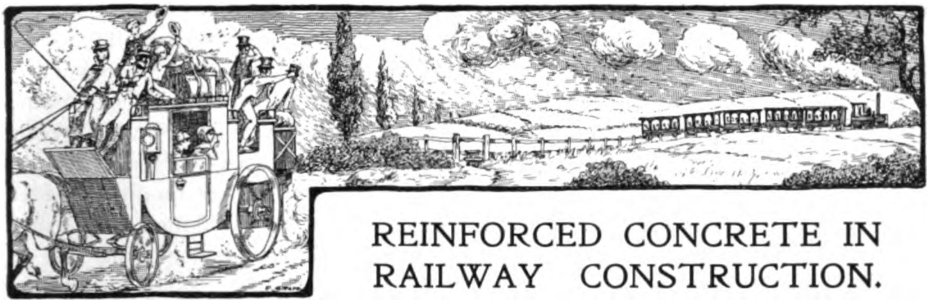


Plan under Second Floor, showing Arrangement of Beams and Pillars.

The new General Post Office at Kingston, Jamaica, for the Crown Agents for the Colonies, has also recently been completed in this system, and in this particular case the building has been designed with a special view to resist earthquake shocks.



Back view of building, showing two of the wings



REINFORCED CONCRETE IN RAILWAY CONSTRUCTION.

As much greater use of reinforced concrete for railway work has been made in America than in this country, the principal examples in this article are taken from the United States, and we are indebted to the Atlas Cement Co. of New York for allowing us to reproduce some of the illustrations which appeared in their recent booklet published on this subject.—ED.

THE use of concrete in railway work is one of extreme importance, and the great developments that have taken place in the last few years are not surprising in view of the undoubted suitability of such a material for work where the question of maintenance is of primary consideration. It is undoubtedly economical for work executed on a large scale, as the bulk of the material required can usually be obtained within easy reach of the site, while the threatened shortage in the timber supply renders it imperative for all engineers engaged in railroad construction to look for a suitable substitute, and it is questionable if any material can be found to equal that of concrete.

The greatest advance has undoubtedly been made by American engineers, and the reason for this is not difficult to find. The European railways have invariably been constructed, in the first instance, in a more or less permanent manner, while the American method has been to use a large amount of timber in bridges, stations, and freight sheds, owing to the great difficulties to be overcome and the corresponding large initial outlay, which prevented the use of more permanent materials until the increased importance and incomes of the railways, together with several disastrous fires, demanded the substitution of more substantial structures. This entailed a gradual reconstruction of the railroads, which began with the adoption of wrought iron in the place of timber, and this was followed by the extensive use of steel; but eventually the adoption of concrete was brought about, and the American engineers have been quick to realise its many advantages.

There is practically no possible use to which concrete cannot be adapted as a building material, and its suitability as a factor in railway work is demonstrated by the many examples described in this article. Its cost is invariably higher than that of timber in the first instance, but it compares favourably with steel in this respect, and the initial cost must not be considered alone, as the maintenance costs of a concrete structure are practically negligible, and it has been estimated that the elimination of painting expenses alone justifies an initial outlay of from 10 to 15 per cent. over the first cost of a steel structure. When compared with masonry or brickwork the cost of concrete is invariably much lower. The durability of concrete is also a great advantage, the strength increasing with age, and its freedom from vibration, owing to its solidity and lack of joints, is also greatly in its favour. When coal is stored in large quantities the danger from fire is very great, and the use of reinforced concrete for bins has been extensively adopted on account of the fire-resisting qualities which it possesses. These qualities render it especially suitable for stations, warehouses and similar buildings. By using sufficient reinforcement, properly disposed to prevent cracks occurring due to shrinkage from temperature, and by carefully mixing and placing the ingredients, concrete can be satisfactorily used without any surface waterproofing, and this renders it very suitable for reservoirs, tanks, dams, conduits and similar structures, which must be essentially watertight. As a material for retaining walls reinforced concrete enables a saving of much space and material, while providing a form of construction which is sound and reliable.

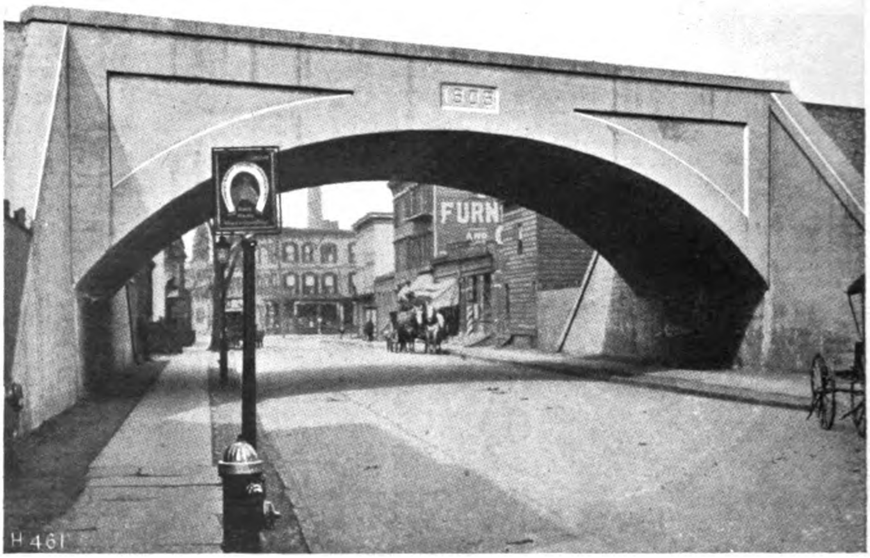


Fig. 1. Railway Bridge at Newark, N.J. Solid Spandril Type.

It is a recognised fact that reinforced concrete needs very careful design and, what is equally as important, very careful execution to ensure success; and, however careful the calculations may have been made and the scheme considered, unless strict supervision is employed to secure good workmanship and the accurate placing of the reinforcement, the work will not be absolutely reliable. The cement must be good and uniform in quality, and the tests made sufficiently severe to guarantee good concrete, if the other ingredients are satisfactory in quality and proportion. The standard specifications should be adopted, as brief specifications are usually incomplete.

The proportions to be adopted cannot, of course, be specified without first considering the nature of the structure itself; but wherever possible the proportions that were actually used for the different examples described in the latter part of this article are given.

BRIDGES.

The construction of bridges is, of course, one of the most important features in railroad work, and the use of reinforced concrete has given highly satisfactory results in this class of construction where designed with intelligence. The easy application to all types renders it invaluable under conditions which would make the use of steel or masonry very difficult, and the minimum amount of material can be employed, with a consequent saving in outlay. The cost of a reinforced concrete bridge is nearly always considerably less than one constructed of masonry or timber, and, when the cost of piers and abutments is considered, a steel bridge can scarcely be said to have any substantial advantage in the matter of expense. In addition, the life of a wooden bridge is about 10 years, and that of a steel bridge about 40 years, and then careful inspection and maintenance are necessary; while a concrete bridge will last almost indefinitely, with practically no maintenance. The track is easily maintained on the latter structure, as ordinary ties and ballast can be used, instead of the more expensive bridge ties of a steel bridge.

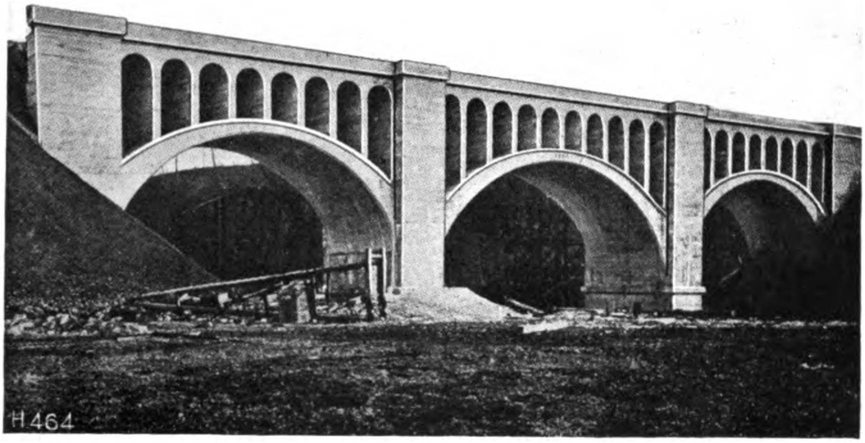


FIG. 2. VERMILION RIVER BRIDGE, SKELETON SPANDRIL TYPE.

Arch bridges can be divided roughly into two types—those with solid filled spandrils and those with the skeleton spandril construction. The former type is usually employed for arches of spans under 100 ft., and where a filling of very poor concrete is employed as a filling between the spandril walls it becomes really a part of the structure. In many cases, however, the filling is executed with earth, sand, or cinders, deposited in thin layers and well rammed in position.

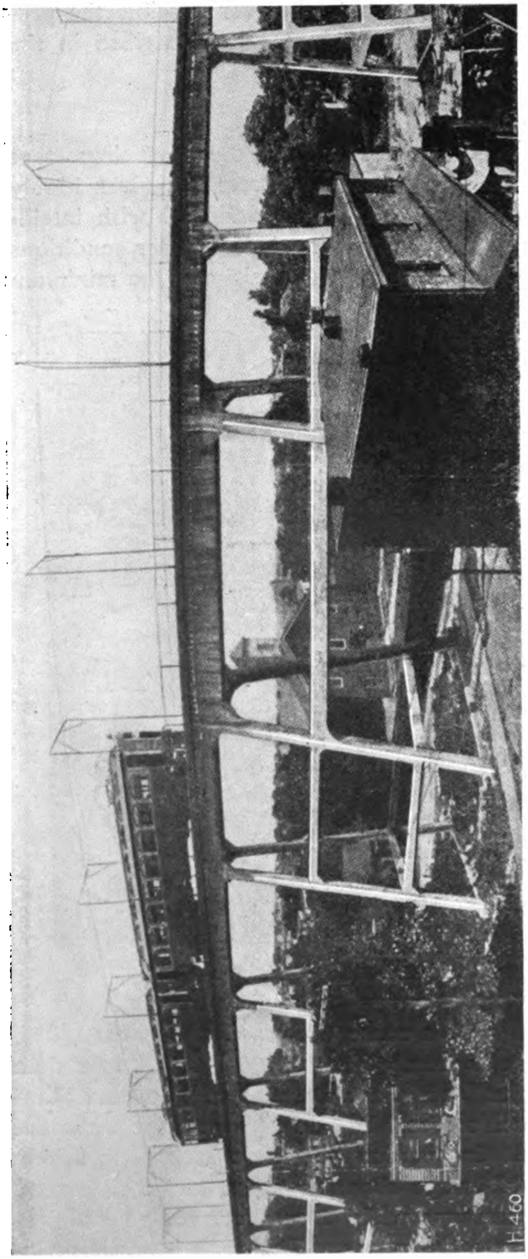


Fig. 3. Richmond Viaduct, Richmond and Chesapeake Bay Railway.

The bridge illustrated in *Fig.* 1 is a good example of the solid-filled spandril type of construction. This bridge consists of a reinforced concrete arch of 54 ft. 3 in. clear span, with axis on a skew of 22° 2′ with the axis of the street. The abutments and wing walls rest on 10-in. piles, the last three rows in each abutment being driven with a batter to correspond with the inclination of the line of pressure. These piles were cut off below water level, which is about 10·87 ft. below the surface of the street, and a bed of broken stone, 3 ft. thick, was rammed around them to within 6 in. of the tops, where the concrete work started. For the arch ring the concrete was mixed in the proportions of one part Portland cement, two parts sand, and four parts 1-in. screened broken stone; while for the abutments and wing walls the proportion was 1 : 3 : 6, with 1½ in. stone; and for the spandril walls 1 : 3 : 5, with 1-in. stone; with the exception of an open expansion joint, like a vertical groove and tongue, between the ends of the abutments and the ends of the wing walls, the bridge was constructed as a monolith. The main reinforcement for the arch consists of $1\frac{1}{4}$-in. curved round rods in both intrados and extrados, placed about 4 in. from the upper and lower surfaces. In the intrados they are spaced 12 in. apart at the springing line and extend 5 ft. past the centre, thus giving a spacing of 6 in. for 32 ft. at the crown. In the extrados they are 12 in. apart at the abutments and carried 2 ft. 6 in. beyond the centre line, thus giving a 5-ft. lap for bond.

At the haunches auxiliary rods, about 26 ft. long, are placed in all the spaces between the main rods. Above and below both the intrados and extrados rods horizontal transverse $\frac{3}{4}$-in. rods are spaced 24 in. apart and extend the full length of the arch. The live load was assumed at 700 lb. per sq. ft. of surface, while the dead load was taken as follows: rails, ties and ballast, 140 lb. per sq. ft. of surface; filling, 100 lb. per cub. ft., and concrete, 160 lb. per cub. ft.

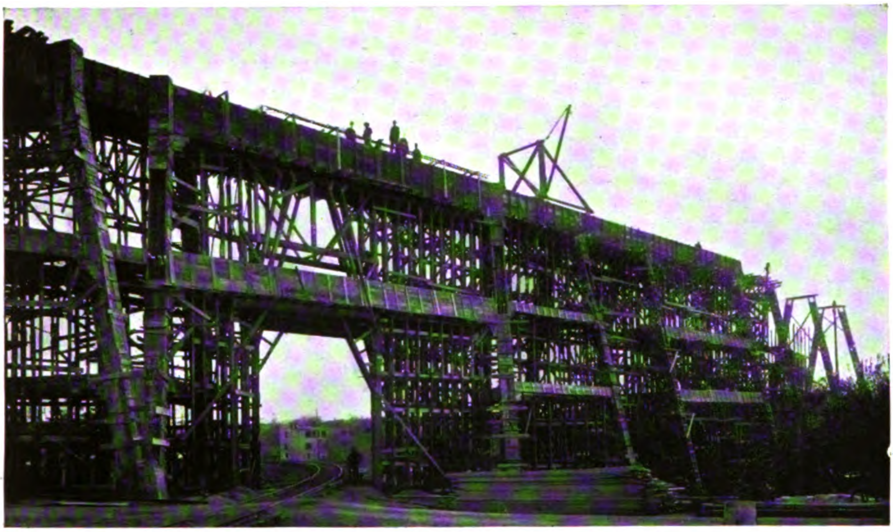


Fig. 4. Richmond Viaduct in course of construction.

Including temperature stresses the maximum stress in the concrete was 600 lb. per sq. in. compression, and 50 lb. per sq. in. shear; while the maximum stress in the steel was 18,000 lb. per sq. in. in tension, and 5,000 lb. per sq. in. in compression, the latter value being fixed, of course, by the permissible stress in the concrete, times the ratio of elasticity of steel to concrete. The concrete in the abutments and the filling behind them was carried to a point about 2 ft. above the spring line of the arch, when the arch was put in at one operation, concreting commencing simultaneously at the springing lines of both abutments. The whole of the concrete was mixed by machinery, and the traffic was maintained uninterruptedly on temporary trestles on either side of the bridge.

An example of the skeleton spandril bridge is that illustrated in *Fig.* 2, which shows the Vermilion River Bridge, and this consists of three arches, the central span being 100 ft. and the two side spans 80 ft., with rises of 40 and 30 ft. respectively. The arch rings are 3 ft. 6 in thick at the crown, deepening out towards the springing lines, and are reinforced near the extrados and intrados with 1-in. corrugated bars, 12 in. apart and overlapped 4 ft. at their ends. Below these rods at the extrados and above them at the intrados there is a series of $\frac{7}{8}$-in. transverse bars, 33 ft. long. Above the arch rings of the main arches the channel piers are hollow, the pilasters being carried up as reinforced facing slabs, 15 ft. wide and 3 ft. 6 in. thick. The transverse walls are formed by the piers of the spandril arches next to the springings, which have brackets at the top projecting 12 in. on the inside. These brackets carry reinforced concrete slabs 2 ft. thick, which, being freely supported on rails embedded in the tops of the piers, and bearing against similar rails projecting from the underside of the slabs, act as expansion joints. A similar transverse expansion joint is placed over the top of each abutment. The concrete in these joints was made as smooth and flat as possible, and finished so that contact between the adjacent faces at the point is made only through the embedded rails. To further separate the division two layers of felt are placed between the two surfaces of concrete and carried up to within 2 in. of the top of the vertical joints, the remaining space being filled with asphalte. The concrete

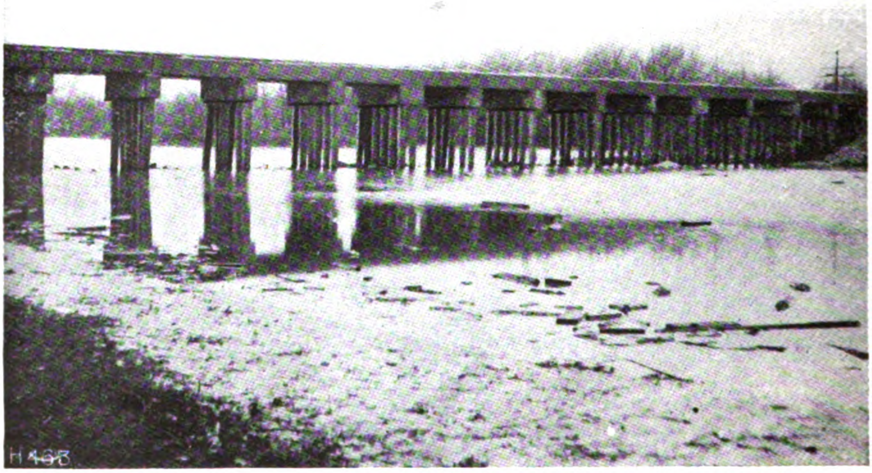


FIG. 5. CONCRETE PILE TRESTLE.

for the reinforced portions was mixed in the proportions of one part cement to two parts clean sand to four parts broken stone; that for the abutments and main piers of 1 : 3 : 6, and the footings of 1 : 4 : 8 proportions.

TRESTLES.

The use of reinforced concrete for trestles is becoming very extensive, and it has proved very satisfactory for this class of work. Very careful design is, however, necessary on account of its light nature, and many conservative engineers do not care to adopt this method of bridge construction. Many very large schemes have, however, been successfully carried out in recent years, and one of the most interesting of these is the Richmond and Chesapeake Bay Viaduct, illustrated in *Figs.* 3 and 4. This viaduct is 2,800 ft. long, while the height varies from 18 ft. at either end to 70 ft. at its highest point.

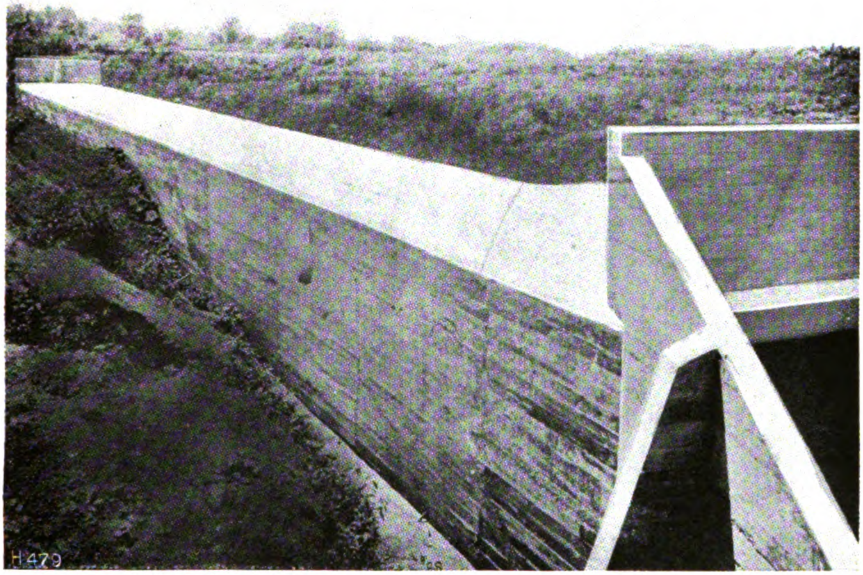


Fig. 6. Indian Creek Culvert before filling.

It was designed to carry a 75-ton car, and it was assumed that the viaduct should carry its dead load and the entire live load, plus 50 per cent. of the live load for impact. An allowance was also made for the thrust, due to the braking of trains, of 20 per cent. of the live load; and wind pressure was figured at 30 lb. per sq. ft. on the surface of train and viaduct. The concrete for the superstructure was mixed in the proportion of one part Portland cement, two parts granite dust, and four parts ¾-in. crushed granite; and in the footings a mixture of 1 : 2½ : 5 was employed. The reinforcement throughout was composed of Kahn trussed bars, and in proportioning the footings a bearing value of 3 tons per sq. ft. was allowed. The viaduct itself is comprised of a system of girders of rectangular cross section, varying in span from 23 to 68 ft., supported by a series of interlaced and battered bents, varying from

14 to 70 ft. in height. Expansion joints were provided where the short girders rest on the column brackets at intervals of about 200 ft., consisting of a grooved steel plate on the top of the bent, on which a grooved steel plate on the bottom of the girder slides. Steel connections are also provided to prevent any tendency of overturning the girder. After the erection of the forms the columns and struts up to the bottom of the girders were poured at one continuous operation. The girders and floors were constructed in a similar manner. The girder sides were removed at the end of a week, while the remaining forms and supporting falsework were left in place for at least thirty days. After the removal of the forms the entire surface of the viaduct was given a finish of sand and cement, applied with a brush.

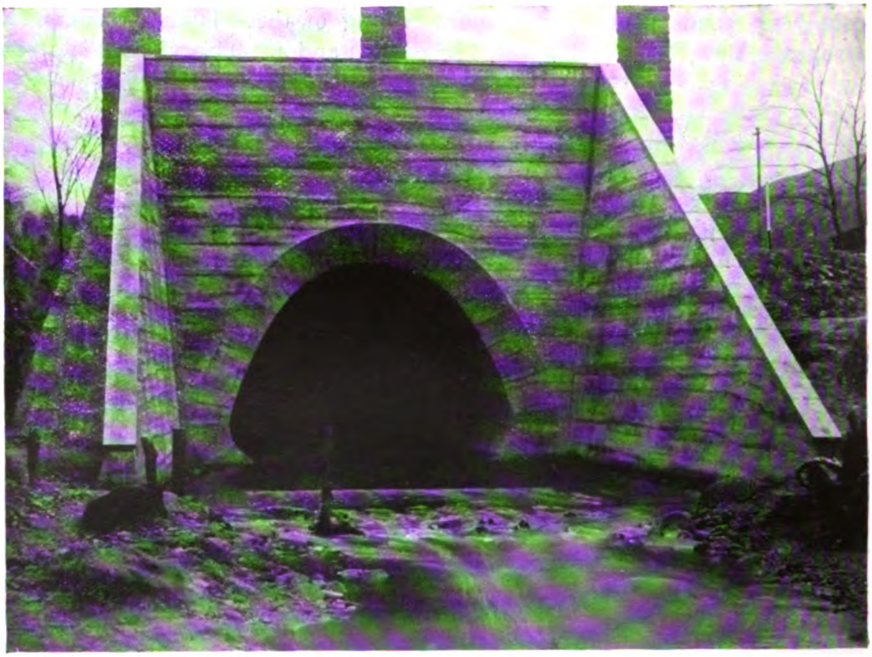


FIG. 7. CULVERT ON THE N.E RAILWAY AT KILTON.

CONCRETE PILE TRESTLES.

These trestles, which replace similar wooden structures, possess a number of features comparatively new to the field of concrete construction. The illustration (*Fig.* 5) gives a general idea of this type of construction, which consists of six pile bents spaced 14, 15 or 16 ft., centres with an average height of 10 ft. Two types of piles are used—namely, rectangular cast piles and Chenoweth rolled piles. The former are 16 in. square at the top, with 4-in. chamfers: and the reinforcement consists of eight ½-in. bars wired to a spiral coil of wire of varying pitch. They are made in lengths up to 30 ft. The Chenoweth rolled pile is circular in section, 16 in. in diameter, and is reinforced with ½-in. corrugated bars, wound spirally with ½-in. mesh wire netting. The piles are driven by an ordinary pile-driver with a 3,000 lb. hammer falling 24 ft., and are finished at the head by deep reinforced concrete cross girders, which support the slabs forming the floor or deck. The concrete for the piles is mixed in the proportion of one part cement to three parts fine screened gravel, while for the caps and girder slabs a mixture of one part cement, two sand and four of stone is used.

CULVERTS.

All classes of culverts have been constructed in concrete, from the small pipe to the large reinforced arch and box types. On account of its greater simplicity, and the less expensive abutments required, the reinforced flat-top culvert, with abutments of reinforced concrete, is more economical for short spans than the arch type. A good example of the box culvert is that illustrated in *Fig.* 6, which shows the Indian Creek Culvert on the Kansas City, Mexico and Orient Railway. This is 250 ft. long and 14 ft. by 15 ft. inside sizes, while an interesting feature in the design is the use of reinforced struts spaced at 8-ft. centres, instead of a solid concrete invert. The reinforcement consisted of ¾ in. corrugated bars, and the concrete was composed of one part cement, three parts river sand, and five parts crushed limestone.

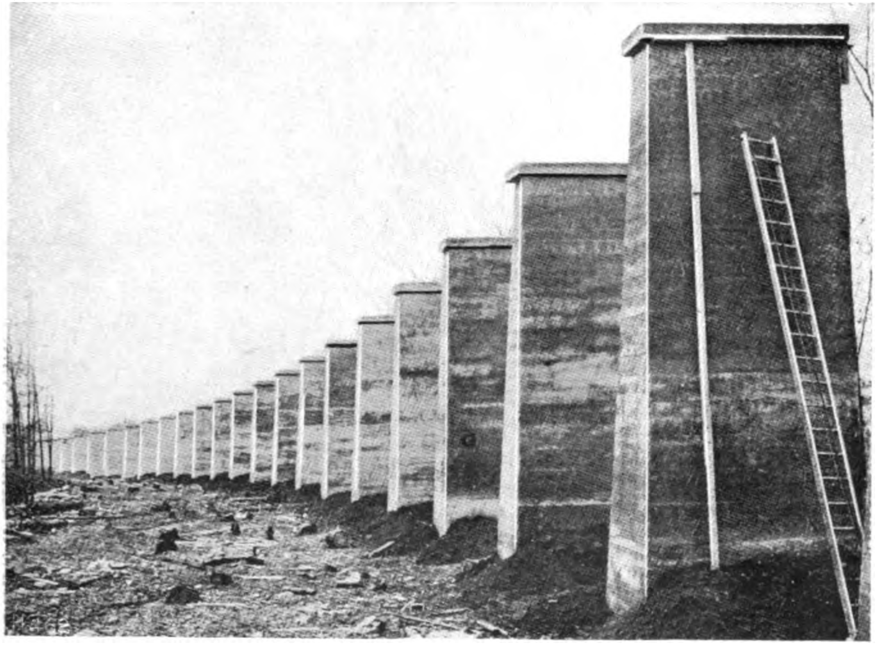


FIG. 8. CONCRETE PIERS ON THE PATERSON AND SUFFERN RAILWAY.

We also reproduce, in *Fig.* 7, a photograph of the reinforced concrete culvert on the N.E. Railway at Kilton, which appeared in our March issue, as being an excellent sample of a railway culvert. The work on this culvert was designed and carried out by the Trussed Concrete Steel Co., of Westminster, S.W.

PIERS AND ABUTMENTS.

Concrete may be used for bridge piers either plain or reinforced. If reinforced concrete be employed there may be quite a saving by reducing the size of the pier or by making it hollow with reinforced walls, in which case the open space is either filled with sand, broken stone or gravel. When it is designed with sufficient stability it is left open, thus making a considerable reduction in the load on the foundation. A good example of these piers is that shown in *Fig.* 8, which is a photograph of some work executed on the Paterson and Suffern Railway. Much use has also been made of reinforced concrete in the construction of abutments for bridges, and the saving in materials has been in some instances so great as to reduce the cost as much as 40 per cent.

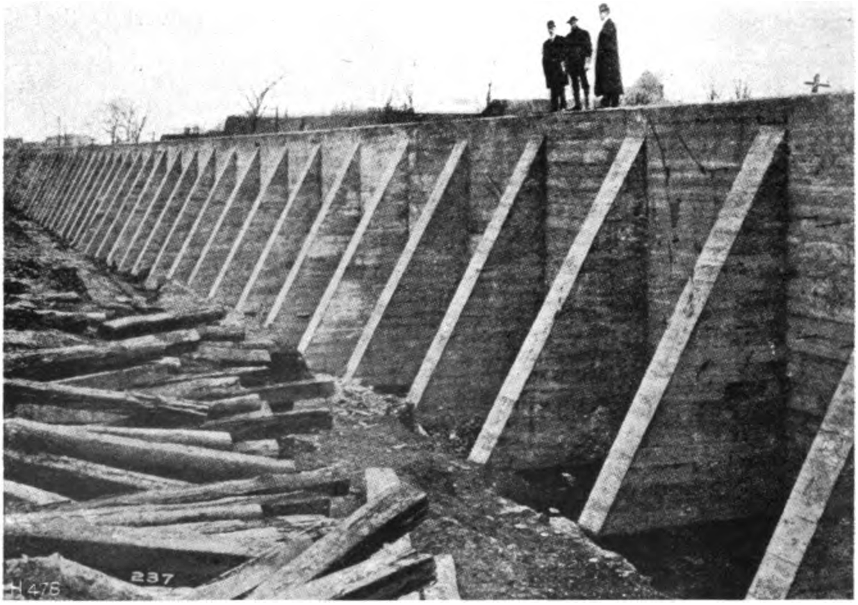
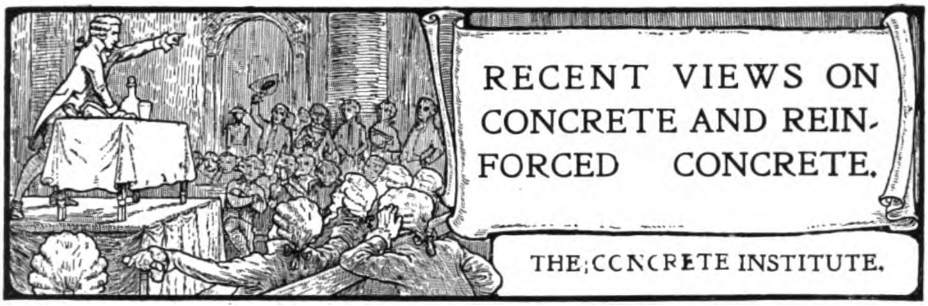


FIG. 9. RETAINING WALL AT BUFFALO.

RETAINING WALLS.

The use of both plain and reinforced concrete for retaining wall construction has become fairly general, and is not confined to railway work alone. Reinforced walls are usually more economical than those built of plain concrete, since the latter type do not allow the material to be fully utilised, because the section must be made heavy enough to prevent overturning by its own weight. With reinforced walls the counterfort type, which is illustrated in *Fig.* 9, is generally economical where the height exceeds about 18 ft. It is necessary in all retaining walls of any considerable length to provide for contraction by placing joints at intervals, and by the provision of enough horizontal reinforcement the temperature stresses can be so distributed that the cracks will be very minute and scarcely noticeable. Careful attention should also be given to the earth filling and its drainage.

The next article will deal with stations and other types of railway construction.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

A GENERAL meeting of the Concrete Institute was held at the Royal United Service Institution, Whitehall, S.W., on March 17th, at which there was a considerable attendance of members and visitors.

The paper on this occasion was by Mr. D. B. Butler, A.M.Inst.C.E., F.C.S., and the discussion was a particularly interesting one. We give a lengthy summary of both.

NOTES ON THE LE CHATELIER BOILING TEST OF PORTLAND CEMENT.

Paper by D. B. BUTLER, A.M.Inst.C.E., F.C.S.

Mr. Bertram Blount, F.I.C., Member of Council of the Concrete Institute, presided.

MR. D. B. BUTLER, Reader of the Paper.

IN the author's opinion, the soundness of Portland cement, *i.e.*, its freedom from expansion ("invariabilité de volume" or "volumenbeständigkeit," to give its French and German equivalents respectively), was its most essential property, and should be always the first thing to be determined in estimating the constructive value of a sample. It was obvious that, notwithstanding other highly desirable qualities which a cement might possess, such as great strength or large sand-carrying capacity, if it was unsound, and contained certain elements which subsequently caused expansion, with, in extreme cases, disintegration and crumbling, it was not only of no use as a constructive material, but was at once converted into a destructive material. Although with the improved methods of manufacture obtaining of recent years these extreme cases of disintegration had become more and more rare, expansion of a more or less dangerous nature was not infrequently met with.

Tests for Soundness.—The original test for soundness, the author explained, was based more or less on working conditions, *i.e.*, pats or cakes of neat cement plunged into cold water when set, or after 24 hours in air, and examined at intervals; if at the end of a month they showed no signs of cracking or distortion, and adhered firmly to the glass plate on which they were made, the cement was considered satisfactory as regards soundness. This test laboured under the obvious disadvantage that 28 days had to elapse before a definite opinion could be pronounced, and the cement finally accepted for use, a delay that was frequently impossible in practice, although it might be argued that the generally specified 28 days' tensile tests laboured under the same disadvantage.

To obviate this long delay, several accelerated tests for soundness have been evolved from time to time. About thirty years ago the late Henry Faija introduced a test for soundness, consisting in subjecting cement pats to 7 hours in moist air of

110° F. followed by 17 hours in warm water of 120° F., which enabled an opinion to be formed in 24 hours instead of having to wait 28 days as formerly.

The next accelerated test was that of M. Deval, brought out about ten years later; after 24 hours in air or under a damp cloth at ordinary testing-room temperature, and 2 days in water of 176° F., the strength developed was supposed to be comparable with that of 1 day air + 6 days in ordinary cold water; while after a further 4 days in hot water, *i.e.*, 1 day in air and 6 days in hot water, the strength developed was supposed to be comparable with 1 day air + 27 days' cold water.

The Boiling Test.—From the 176° F. of the Deval test it was but a step to the boiling test now in vogue, and having regard to the difficulty of always maintaining an equable temperature of 170° F., the boiling test is certainly considerably simpler; the ordinary qualitative boiling test consisted of allowing a pat to set 24 hours in a damp box of 60° F., and then placing it in cold water, which was gradually raised to boiling and maintained at that temperature for 6 hours, after which treatment the pat should show no signs of warping or cracking; it was sometimes further specified that the edges of the pat should also break off with a sharp crisp ring, which was a very sure indication that it was free from cracks or flaws of any kind.

The foregoing tests were all of a qualitative order, and depended more or less on the personal experience of the operator as to whether the results obtained were seriously defective or not.

Bauschinger Apparatus.—The most accurate quantitative method of measuring expansion or contraction, whether in air, cold water, or by the various accelerated tests, was the Bauschinger micrometer calliper apparatus, in which the test pieces consisted of prisms or square bars 100 mm. long and 22 mm. by 22 mm. cross-section; the delicacy of the instrument was such that variations in the length of the bar to within $\frac{1}{200}$ mm., or 0·005 per cent., could be determined with certainty. It, however, required very careful expert handling, and was somewhat expensive, the equipment, including moulds, costing about £12.

The Le Chatelier Test.—The only other quantitative method of note for determining expansion was that devised by M. Le Chatelier, which was adopted by the British Standards Committee in 1904 as the standard method of determining the soundness of cement. The description and method of working, taken from the revised British Standard Specification of 1907, were as follows :—

> "The cement shall be tested by the Le Chatelier method, and shall in no case show a greater expansion than 10 millimetres after 24 hours' aeration and 5 millimetres after 7 days' aeration.
>
> "The apparatus for conducting the Le Chatelier test consists of a small split cylinder of spring brass or other suitable metal of 0·5 millimetre (0·0197 inch) in thickness, forming a mould 30 millimetres ($1\frac{3}{16}$ in.) internal diameter and 30 millimetres high. On either side of the split are attached two indicators with pointed ends, the distance from these ends to the centre of the cylinder being 165 millimetres ($6\frac{1}{2}$ in.).
>
> "In conducting the test, the mould is to be placed upon a small piece of glass and filled with cement gauged in the usual way, care being taken to keep the edges of the mould gently together while this operation is being performed. The mould is then to be covered with another glass plate, a small weight is to be placed on this, and the mould is then to be immediately placed in water at a temperature of 58 to 64 degrees Fahrenheit, and left there for 24 hours.
>
> "The distance separating the indicator points is then to be measured, and the mould placed in cold water, which is to be brought to boiling-point in 15 to 30 minutes, and kept boiling for six hours. After cooling, the distance between the points is again to be measured; the difference between the two measurements represents the expansion of the cement, which must not exceed the limits laid down in this specification."

It certainly had this advantage over the Bauschinger apparatus, that it was cheap and simple, and involved no costly apparatus, but whether it was equally accurate was open to discussion. In the course of ordinary professional testing work, the author stated he had had to carry out many thousands of tests for soundness by the Le Chatelier method, and the conflicting results he had sometimes obtained had led him to the conclusion that where the condemnation of a cement for unsoundness was concerned, the results given by the Le Chatelier test should not be too rigidly interpreted.

The author then quoted a series of experiments to show the variable results which might be obtained by different operators, and even by the same operator working under exactly the same conditions.

In order to ascertain if differences in the elasticity of the moulds were in any way responsible for the variable results obtained, the author devised a special apparatus. The variation given by different moulds was considerable. However, the results did not definitely point to differences in the elasticity of the mould as being responsible for the variable results obtained, since No. 10, which was an extremely weak mould, gave the least expansion in two cases out of three.

It was thought possible that the position of the test pieces in the boiling bath, whether in the centre or round the outside, might have had something to do with the variations found, and tests were therefore made to ascertain if this were so, but the results suggested that this was not the case. Nor did variations in time of cooling after boiling appear to affect the result in any way.

Differences Due to Aeration.—Another curious feature about the Le Chatelier test was that instances were very frequently met with in which the expansion was considerably greater after 6 days' aeration of the sample than when first received, or after only 24 hours' aeration. From the point of view of a test for soundness this was an obvious absurdity, since it was a well known and thoroughly acknowledged fact that cement improved with aeration as regards soundness; it therefore very strongly suggested that the increased expansion of such samples upon boiling was due to causes altogether outside the question of soundness as it was generally understood, *i.e.*, the presence of disruptive agencies within the cement itself, which would eventually cause expansion under ordinary working conditions.

Less Expansion on Boiling than in Cold Water.—In a paper read before the Concrete Institute in May last on the setting properties, etc., of Portland cement, Mr. H. K. G. Bamber referred at considerable length to the Le Chatelier boiling test and raised one or two very interesting points. He first of all drew attention to the fact that the expansion of the specimen during the preliminary 24 hours' immersion in cold water was altogether ignored, only the subsequent expansion during boiling being taken into account, and pointed out that instances frequently occurred in which the expansion in cold water was considerable, whereas that resulting on boiling was negligible. The author of the present paper said he could fully bear out that statement, for it was the custom in his testing-room to record in every case the expansion caused by previous immersion in cold water, as well as after boiling, and in many cases, more especially with slow-setting cement, the expansion in cold water was very much more serious than that due to boiling.

Surely it was more important to record the expansion under actual working conditions in cold water than that produced by boiling, for whatever the value of boiling as an accelerated test for soundness, cement was rarely, if ever, subjected to boiling water in practice.

Slowly Hardening Cements. — Mr. Bamber also referred to the somewhat arbitrary condition of only allowing the cement 24 hours to harden under water, before being subjected to the boiling water, and suggested that failure was frequently due to the cement, more especially the slowly hardening varieties, not having had time to sufficiently harden in that brief period to withstand boiling water; he gave an instance in which cement tested under British Standard Specification conditions gave 15 mm. expansion, but when allowed 3 to 7 days' preliminary hardening under water, the expansion was reduced to 10 mm. and 1·5 mm. respectively, while, if allowed 24 hours' hardening in air, instead of water, there was no expansion whatever.

Expansion of Coarse Particles.—Referring once more to Mr. Bamber's paper, the author gave as one reason of cement sometimes failing to pass the Le Chatelier test, the inability of the coarse particles, or unpulverised clinker, to withstand boiling water without expansion, and expressed the opinion that "it has yet to be proved" that because such unpulverised material caused expansion when submitted to boiling water, that it would also cause expansion under ordinary working conditions in cold water. With this the author quite agreed, and quoted experiments which showed that there was something in the contention.

Conclusions.—The experiments embodied in the paper, taken as a whole, appeared, the author suggested, to justify his remark at the commencement, that where the condemnation of a cement for unsoundness was concerned, the results given by the Le Chatelier boiling test should not be too rigidly interpreted. Apart from the mass of anomalies and conflicting results continually met with, it was quite an open question whether a cement should be condemned as unsound because it would not withstand boiling water 24 hours after gauging, whether that 24 hours' preliminary hardening was in cold water or in air. On this point it was a significant fact that in the German Standard Rules for testing cement, which have been in operation for many years past, and also in the recently revised Rules, which the author understood only await Government sanction before issue, accelerated tests for soundness were altogether ignored, reliance being placed on the 28 days' cold water test mentioned at the commencement of this paper. The matter of boiling and other accelerated tests was very thoroughly investigated by the German authorities some few years ago, and having regard to the leading position which German technologists have always held in matters relating to cement, it was worthy of note that such tests were found to be unreliable, *i.e.*, as being liable to condemn good and bad cement alike.

In America, too, there seemed to be considerable difference of opinion as regards the value of boiling tests. The American Society of Civil Engineers' Specification included the following accelerated test, as well as normal cold water tests: "A pat exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for 3 hours," the preliminary hardening being in cold moist air. The closing paragraph of the Specification is, however, rather significant, *i.e.*:—

> "In the present state of our knowledge it cannot be said that cement should necessarily be condemned simply for failure to pass the accelerated tests; nor can a cement be considered entirely satisfactory simply because it has passed these tests."

Whatever excellent reasons there might be for or against accelerated tests, the author could vouch from personal experience for the fact that considerably less than twenty years ago not 10 per cent. of the Portland cement manufactured in England or elsewhere would withstand boiling water under the foregoing conditions; the obvious inference, therefore, was that if such was a true test for soundness, 90 per cent. of the cement used twenty years ago was unsound. This, in view of the hundreds of thousands of tons then used for important engineering work throughout the world, was rather a startling proposition; and having regard to the excellent condition of such work at the present time, was one that could scarcely be seriously maintained.

THE CHAIRMAN.

It was a very pleasant duty and privilege for him to ask them to give the heartiest thanks at their disposal to Mr. Butler for his paper, which was admirable in every way for its contents, for the labour that it involved, and for its perfect lucidity and impartiality. He would also like to be allowed to make a brief comment on the various conclusions. Mr. Butler appeared to suppose that, because certain nations, the German and American, in short, had failed to prepare cement of the admirable quality made here and in other countries we should go back and put the clock some 20 years behind the times. He thoroughly disagreed with Mr. Butler there, and that was the summary of his criticism. He would now ask Mr. Bamber to open the discussion.

MR. H. K. G. BAMBER, Assoc.Inst.C.E., F.C.S.

He took it as a great honour to be called upon to open the discussion upon this most interesting paper. He would first of all add his congratulations to the author for the very estimable way in which he had dealt with this subject. Mr. Butler had rendered a conspicuous service, not only to the engineering profession, but also to the cement trade, in raising the questions that he had done in his paper, the discussion of which tended to elucidate those difficulties which were so prominent at the present time in connection with this matter before the engineer and the cement manufacturer.

The Faija Test.—Mr. Butler had dealt with the subject from a somewhat comparative point of view, insomuch as he had described the various methods of testing the soundness of cement. He puts first and foremost the Faija test. He (Mr. Bamber) was not quite certain whether that was done by reason of its importance or of its antiquity. In his opinion, which was very much that of the Chairman, the test, good as it was in the past, and good as it was to-day, had become somewhat out of use by the cement manufacturer by reason of the fact that the manufacturer knew that if any cement he made failed to pass the Faija test it must be bad indeed.

Deval Test.—Mr. Butler then described the Deval test, which was certainly a much more severe test than the one which he (Mr. Butler) continuously recommended. Speaking as a manufacturer, he had looked upon the Deval test as one of the most important which the manufacturer had at his command. His experience, which was somewhat large in this matter, had led him to the conclusion that, if any cement for which he was responsible was capable of passing this Deval test—which was a test which extended over a period of seven days—there was not the slightest necessity for any mental disturbance of the kind Mr. Butler had referred to. For his part he considered the Deval test as the most satisfactory one, from the expert's and also from the manufacturer's point of view, that could possibly be invented.

Mr. Butler then got on to the more severe test of boiling, and described later Dr. Erdmenger's and Dr. Heintzel's methods, but he had omitted a test, which was known technically in the trade as the boiled balls test. This consisted of mixing up a certain quantity of cement, and placing it in a piece of linen, and immersing it in a receptacle which contained water, and boiling it for a certain period.

Le Chatelier Test.—He was glad to see that Mr. Butler described the Le Chatelier test as a cheap and simple one, and he quite agreed with the remark of Mr. Butler that the results of this test should not be too rigidly interpreted. His experience of this test had been that when questions had arisen between the manufacturer and the expert in connection with the slight variations or excesses over specification requirements, where the manufacturer had had an opportunity of discussing the matter with the engineer, together with the expert, in almost all cases the engineer was willing and anxious, knowing the severity of the test, to waive any very distinct line of demarcation in connection with acceptance or rejection.

Under the heading, "Variations in Time of Cooling After Boiling," Mr. Butler said: "It is frequently desirable, in order to save three days' delay, that moulds should be filled on Friday, and consequently boiled on Saturday. Since the requisite six hours' boiling is not completed until after the usual Saturday working hours, the only way in such cases is to instruct some responsible person resident upon the premises to turn out the gas under the boiler at a certain hour and leave the moulds in cold water till Monday morning before measurement." Now, the first thing that struck him in connection with that was that the expert perhaps should devise some better method of automatically cutting off the gas than by leaving it to some responsible person to turn out in the course of the night.

Expansion in Cold Water.—Mr. Butler also referred to certain remarks which he (Mr. Bamber) had made in a paper which he read recently to this Institute, and he was glad to see Mr. Butler agreed with him that some alteration should be made in the Le Chatelier test to deal with the expansion which sometimes took place in cold water before the cement was boiled. In nine cases out of ten where that preliminary expansion in cold water took place it was due more or less to the presence of gypsum in certain proportions. As a result of communication with M. Le Chatelier, who had not noticed this peculiarity in connection with his test, he himself suggested it would be a good thing to modify the test in some form so that this expansion in cold water might be recorded. M. Le Chatelier was good enough to say he would investigate this particular point, and that he thought the particular apparatus which was now in use was not perhaps sufficiently delicate to determine this preliminary expansion, and he suggested, or offered to make some suggestion, as to some modified form of apparatus whereby this preliminary expansion might be determined. He had not yet heard from M. Le Chatelier with reference to this point, but Mr. Bamber thought it was one which should be dealt with, because he was firmly of opinion that a cement which expanded considerably in cold water was more dangerous than one which was perfectly sound in cold water, and expanded only when boiled.

Mr. Butler again referred to the probability of the expansion in the Le Chatelier test being frequently caused by the greater particles of unground clinker present in the cement. He was glad to see that Mr. Butler's tests and his experiments practically confirmed that opinion, but he would have felt more satisfied if Mr. Butler could have told them why these particles of cement expanded when boiled, and the finer particles of cement, which were entirely of the same chemical character, did not expand.

With respect to the author's conclusions, it was generally accepted by the cement trade that the Le Chatelier test was one which could be complied with; and, in his opinion, the engineer, whatever his views might be as to the comparative value of the test recommended by Mr. Butler—the Faija test as against the Le Chatelier test—must at least come to the conclusion that in purchasing his cement it was better to have that which would pass the more severe test, even if it was too severe, than one which would not do so. He would again reiterate that he thought, in respect to the improvement in the quality, the Le Chatelier test had been of more value to the cement trade in this country than anything they had ever had put before them. He believed every cement manufacturer of any repute had put himself in a position to comply with it. He would be sorry to see a return to the less severe tests invented by Faija some twenty years ago.

MR. W. J. COOPER, F.C.S.

Since its inception he had taken the greatest interest in the Le Chatelier test, and to a certain extent was in accord with it; but on some points he was not, as it seemed to him to be based on a wrong foundation. It was assumed that the combinations which took place in the case of a cement in contact with water at a temperature of 212° F., were the same as those which occurred at lower temperatures, say, up to 100° F. That point, so far as he was aware, had not been proved.

Effect of the Test.—As far as the effect of the test was concerned, he was prepared to grant that in the majority of cases, if a cement complied with it satisfactorily, it was sound and could be relied upon in every way; but he did not think that this could be taken as an invariable rule, because he knew numerous instances where a cement had given little or no expansion when boiled in the Le Chatelier mould, but had ultimately failed by expansion, and in one case, at least, had disintegrated on its own account. On the other hand, if a cement failed to comply with the test, he really could not say that such failure was any evidence that that cement was unsound. There were many reasons why this view should be taken, one of which was that cement, whether quick setting or slow setting, was boiled after setting for an arbitrary period—*i.e.*, in 24 hours after gauging. Perhaps in the majority of cases this time might be sufficient, but in other cases it certainly was not. He had one case before him where a cement, when boiled for 24 hours, gave an expansion of 40 mm. He knew the cement was sound. It was one with which he had made extensive experiments, and he therefore made a large number of pats or blocks, and boiled them at varying periods after gauging. As the period of time between gauging and boiling increased, so the expansion decreased. It started at 40 mm. at 24 hours, and it gradually shrunk down to 2 mm. at 28 days. At three months the expansion was absolutely nil, either in cold water or on boiling. That cement would have been condemned as a very bad sample, as a very unsound cement, if judged only by the Le Chatelier test. If it had been so, when boiled at three months its unsoundness should have developed and have become apparent. Instead of that there was no expansion in the sample when taken from the cold water before boiling, and boiling produced no further expansion. Not satisfied with boiling this three months' old sample for six hours, it was kept boiling for 24 hours, and the expansion was still nil. He therefore thought that if a cement failed when boiled 24 hours after gauging, it should not be judged guilty, but should be allowed to produce some evidence of its soundness by being given an extension of time, and a further sample boiled after setting for, say, three days.

Aeration.—It was generally admitted that a cement which was spread out and aerated was improved in soundness. Now, in his experience—which covered a great variety of cements, including that burnt in rotatory kilns—he found not infrequently that a cement got worse on aeration. Singularly enough, he had an example in his own manufacture only last week. A sample was taken direct from the mill spout and gauged, five minutes after grinding that sample gave an expansion of about 8 mm. It was allowed to stand six hours, and a further sample gauged. It then gave an expansion of about 12 mm. It was then aerated for 24 hours, and a further sample gauged, when the expansion jumped up to somewhere about 30 mm., and that expansion increased for some time with aeration, but eventually began to recede. Now, that same sample of cement when allowed to set, after being gauged, for a longer period than 24 hours, gave normal results. He had yet to learn that any satisfactory explanation had been advanced as to why a cement should apparently become more unsound after aeration.

Mr. F. T. Tristram: You mean unsound on boiling?

Mr. Cooper: He meant unsound as judged by the test in question, which, in his opinion, did not always indicate genuine unsoundness.

Expansion of Cement in Cold Water.—Mr. Bamber made some remarks with regard to the expansion of cement in cold water. He was very much interested in the statements he put forward in his paper on the "Setting of Cement," and he (Mr. Cooper) had carried out some experiments which at first appeared to contradict them, and wrote to Mr. Bamber to that effect. Since then he had carried out many more experiments, and he found in some cases that the addition of gypsum to cement, which expanded considerably in cold water and also considerably on boiling, reduced the expansion in cold water—in some cases it became absolutely nil. It also reduced the expansion on boiling in other cases, and he thought these were in the majority. Further experiments showed that the expansion in cold water was sometimes increased by the addition of gypsum, and he found that when the expansion in cold water was considerably increased, the expansion in hot water was sometimes almost completely abolished.

MR. GORDON NICOL, M.Inst.C.E. (Engineer to the Aberdeen Harbour Board.)

For the last 16 years he had carried out the boiling test of cement, and carried it out very rigidly, and perhaps rather more severely than others, because he had always specified, after gauging and remaining in a moist atmosphere for 24 hours, that it should be boiled for 48 hours, his impression being, from some of the tests carried out, that in a comparatively short period the cement might escape detection, where in the longer period it would necessarily be detected. Of course, it might be argued that it was too severe a test, and he could quite understand the manufacturer arguing that point, but at the present moment they did get the cement manufacturer to stand this test. Most of the cement which he was using passed such a test, and until one had discovered another which was more reliable he thought the engineer would like to be assured through this that his cement was sound. Personally he felt that it did to a considerable extent test the soundness of the cement. The Le Chatelier was one which he had used for some time so that he might comply with that portion of the British Standard Specification, but certainly it was on a longer period of boiling that he had always determined whether, in his opinion, the cement was suitable for the work.

Causes of Unsoundness.—It had been said that the core really was somewhat responsible for the deterioration or disintegration which took place under this boiling test, and he remembered on many occasions, when visiting the cement factories, having taken the tailings from the wet grindings and discovering a considerable number of particles which had not been reduced in the process of wet grinding, and he had always held the opinion that that to a great extent had been the cause of the disruption that took place in the cement, those particles not being reduced, passing into the fuel and having considerable volume in themselves, being prevented from chemically uniting with the other ingredients in the cement, but having that little kernel of what became caustic lime in the centre, and this hot water reaching the little kernel and causing the disruption.

There might, of course, be other causes, such as free lime or overliming, which caused the unsoundness, and it might be said that this test was one which subjected the cement to conditions which it would never meet in practice—that the cement, practically speaking, in the large mass of work was never subjected to boiling water, and never subject to an excessive temperature of any kind. That was a point on which he felt at a loss altogether, as regards explaining what the effect of the boiling water was in penetrating the cement, in getting to these little particles which were considered as embedded in the mass and ultimately causing the rupture.

Test for Unsoundness.—He had had many cases where cements had given way and where large expansion had taken place, the expansion in the 48 hours reaching about 25 per cent. of the length of the testing place. But latterly he had felt that even a more severe test to apply to the cement for soundness was that of breaking the bricquettes, after the boiling, and comparing them with the strength of the bricquettes before boiling, and he specified that the cement hydrated, kept in the moist atmosphere for 24 hours, and boiled for 48 hours was to be compared with a bricquette in the moist air for 24 hours and put under water for 48 hours, to make it the same age as the boiled bricquette, when it was taken from the boiling water; that that bricquette should show an increase of tensile strength of 30 per cent. It might appear to be a very severe requirement in the cement, but he got it, and the manufacturer did not object to give it, and he discovered in that test the acceleration of the strength while showing no disruption of the material; and recently in one of the cargoes that he used in effecting this test the unboiled bricquette at three days gave a tensile strength of 714 lbs., and the boiled bricquette at three days gave 970 lbs. tensile strength. Whether that had a connection with the soundness or the unsoundness of the cement he was not prepared to say at the moment, but he felt that the accelerated test was not only one which should be used for the acceleration of the tests in the cement, but also to show the acceleration of the strength.

He had to express his indebtedness to Mr. Butler for the most excellent paper which he had given. He was sure that he (Mr. Butler) had not suggested that they should leave boiling tests at the present moment without some very good reason, and until they did get a test which would satisfy the use of the cement to improve its soundness he thought that they must adhere to the boiling test.

MR. F. T. TRISTRAM.

He had carried out a great many experiments with the Le Chatelier test, and there was no doubt it was very variable, but all tensile and other tests were the same. It was largely a matter of the personal equation. He would like to mention first the elasticity of the moulds which Mr. Butler referred to. He also had found out there was a slight variation there; in fact, he had got a mould, an excessively useful mould, which he would not part with for anything. It invariably showed less expansion after boiling than when the original measurements were taken.

Expansion.—His experiments had been more with the intention of trying to find out what was the action of boiling water on the cement, which frequently caused expansion in an apparently otherwise perfectly sound cement. He thought there were various reasons for the expansion indicated by the Le Chatelier test. Firstly, by faulty manufactured, overlimed, or badly calcined cement, but he always found in those cases that aeration would cure it; secondly, in a well-manufactured, hard, burnt cement, which might be due to increase in volume; thirdly, by the cement being slow-setting and not hardening sufficiently before being boiled.

When one came to deal with a cement which, for instance, he used for his experiments, which gave 9 mm. expansion at first, and after aerating for 24 hours, 7 days, and 14 days, still gave the same expansion of 9 mm., he maintained if that had been caused by the presence of free lime the expansion would have gone down. Then he started to work on the grit to see to what extent it was responsible for the expansion. The cement which was rotary was quite normal in composition, was ground, leaving 14 per cent. residue on the 180 sieve and all other tests satisfactory. First he examined the grit under a microscope and found it was entirely composed of very hard, dense, and partly fused particles. There was no trace anywhere in this grit of any half burnt. In order to try and find if there was any expansion in the grit itself, he took a cement as a binding agency, which, after repeated tests, gave no expansion whatever on the Le Chatelier. He did not know how Mr. Butler made his experiments, but he found great dificulty to get his grit to stick together and form a dense mass unless something was used.

Of course, the question ot interest to users really was as to what was the connection or the ratio between the expansion of a cement when boiled and the expansion of a cement in ordinary use, and he did not know what experiments had been carried out to try to come to some conclusion on that point.

He himself had found that, as a rule, a well manufactured cement would not crack a test tube until it reached from 30 to 35 mm. expansion on the Le Chatelier test, but he would like to have some expression of opinion from Mr. Blount or Mr. Butler on this important point.

MR C. H. WATSON, Assoc.Inst.C.E.

Generally.—He had always been an advocate for the Le Chatelier test from its inception, or really from the time we first had it in this country. And one of his reasons for that had been, first of all because he thought that it was what one might describe as a scientific test, and that the method of measuring the expansion was so reliable, and that one could record it ; that altogether it was an extremely satisfactory test.

He was obliged to confess that his experience recently, and some of the figures which Mr. Butler had given, would almost tend to shake one's confidence a little in this test ; but he did think that all these, what one might call vagaries and eccentricities of the Le Chatelier test, were quite capable of explanation.

He quite agreed with what Mr. Butler had said in the early part of his paper, that he did not think that the Le Chatelier test was so emphatic as that one could either pass or reject a sample of cement purely and simply on that, provided the other tests were satisfactory, because the Le Chatelier tests varied occasionally from other causes than that dependent upon the quality of the cement, probably what one might describe as physical causes.

He did not think that any engineer or any manufacturer need be in the slightest degree alarmed with regard to expansion in cold water before boiing. Mr. Bamber stated that he thought that that was probably due to the presence of gypsum. In his own opinion it was due really to what might be called physical conditions—that is to say, that the majority of cement, nowadays, required by engineers was a slow-setting cement, and a slow-setting cement really allowed what might be described as an incursion of water into the sample. When it is then placed in the boiling pot the expansion which took place at that time, before being placed into this pot, was due largely to the physical condition of the incursion of water into that sample, and he did not think it was due, or had anything to do with the soundness of the cement whatever.

The same argument applied, in his opinion, to the question of why they got expansion with the grit as against the very fine cement. If a very fine cement was used, well, then, they got a close substance and probably a quicker setting, an increase of water was prevented, and also the expansion which took place with a coarser material which allowed the water to get into the sample.

He had himself carried on a whole series of experiments. He took a sample of cement and divided it into five parts, and laid all these five parts out in his laboratory and kept on testing these every day for 14 to 28 days. The most extraordinary results ensued. Some of the samples had only 2 mm. expansion at the first 24 hours when fresh, some of them had 8. Finally, at the end of 28 days he ended up as he had begun—namely, with 2 mm. expansion. Under those circumstances, he thought that those physical conditions affected the Le Chatelier test very materially, and therefore he came to the conclusion which he mentioned before, that it was not a test upon which cement should be rejected or passed unless taken in conjunction with the other tests of the British Standard Specification, but at the same time he thought that it was an extremely useful test, both for the manufacturer and the consumers.

MR. LAWRENCE GADD, F.I.C.

- ***Aeration.***—The first point he wished to refer to was Mr. Butler's remark on the differences due to aeration, when he mentioned that a curious feature about the Le Chatelier test was that instances were very frequently met with in which the expansion became greater when the cement was aerated. He gave 12 fairly recent samples in which this had taken place. He (Mr. Gadd) was not surprised at that, because he had seen cases of that sort literally by scores, and as far back as 1907 had published an article on this very test, in which he said that his experience then led him to believe that in the majority ot rotary cements as then manufactured the expansion would increase upon aeration, and he mentioned then that the average increase of expansion on aeration was somewhere between 3 and 12 mm., which curiously enough was absolutely borne out by the figures in Mr. Butler's paper. This was as the result of experience which was not confined to British cements, but included European and American cements also. Cement manufacturers had, however, found means since then of meeting the more stringent requirements of the consumer's tests, and he did not find the increase of expansion on aeration nearly so frequent nowadays as a few years ago; but at the same time he thought everyone who had much experience in this Le Chatelier test must come across instances now and then, at any rate, even to-day, where on aeration a larger expansion was obtained than before.

Expansion in Cold Water.—Another important point was expansion in cold water, raised last May in this room by Mr. Bamber, and which was perhaps of more importance than the expansion in boiling water, because it came more nearly to the conditions in actual practice, although it ought to be remembered that in actual practice cement was rarely used neat, and the expansion practically disappeared when the cement was mixed with sand. His experience, contrary to that of the last speaker, led him to conclude that expansion in cold water was nearly always due to the presence of calcium sulphate, generally in the form of gypsum or plaster, and he thought it was due almost entirely to the formation of sulpho-aluminate of lime, as first pointed out by Caudlot.

Another speaker had mentioned that although sulphate of lime had a tendency to cause a certain degree of expansion in cold water, it appeared to reduce the expansion when the cement was afterwards boiled, and he could quite endorse that. Some few years ago he carried out a series of experiments on nearly 200 cements, and had plotted the results. The curves obtained showed an almost symmetrical relation between the proportion of calcium sulphate and the Le Chatelier expansion figures. In some cases an amount of calcium sulphate, equal to 2 per cent. of gypsum, reduced the expansion in boiling water by 6 or 8 mm.

With regard to the author's remarks on the expansion of the coarse particles, these were especially interesting to him, because he thought he was the first investigator to point out the influence of fine particles of grit on expansion in the Le Chatelier test; but Mr. Butler appeared to him to have lumped together the whole of his residue on the 180-mesh sieve, and called that grit; and he also called flour or fine material, everything that passes through the 180-mesh sieve. But he (Mr. Gadd) had shown previously that the larger particles of residue—that is to say, residue which is retained upon the 76-mesh sieve, had no influence whatever on the expansion. It did not make any difference whether you removed them from the cement or put them in; these larger particles did not cause the expansion. The particles which did cause the expansion, which did the damage, were much smaller particles, some of which would pass readily through the 180-mesh sieve, and were not all retained except on a mesh of something like 240. The author did not offer us any explanation as to why these particles should cause expansion, but he (Mr. Gadd) in the *Engineer* of September 13th, 1907, had offered an explanation which might possibly be the true one.

MR. J. F. PLAISTER.

Expansion in Cold Water.—A point which had not been raised was in connection with the expansion in cold water. He agreed with Mr. Watson that that was really a physical defect in the test. He had made many experiments with the same cement, with gypsum and without gypsum, and he had found where it expanded in the cold water without gypsum, that with the addition of a certain amount of gypsum it did not expand anything like so much. He put that down a great deal to the nature of the clinker from which the cement was ground. He thought most manufacturers who were acquainted with the rotary system of burning clinker would bear him out that at times it varied very much in toughness, dependent a great deal on the nature of the fuel used to burn it; and what he found was that where a very tough clinker was used one got the greatest expansion in cold water, and he put that down more to the fact that there was not the same amount of flour in cement ground from tough clinker, and therefore there was a larger absorption of water after the mould was placed in the tank and there was a sort of miniature volcanic action set up during the boiling process. It was most remarkable that directly you put something in the shape of flour, it did not matter whether it was gypsum or anything else, into cement made from that class of clinker, you reduced the expansion in cold water. He had made some 300 or 400 tests on those lines, and they all confirmed the same view.

MR. W. L. H. ROBERTS.

Manufacturers would endorse that the better the clinker, the finer the clinker; but the harder the clinker, the more difficult it was to satisfy the Le Chatelier test. When the clinker was moderate and did not carry quite such a large tensile strain, it would easily pass the Le Chatelier test; but when they got the very finest clinker that could possibly be produced, then the Le Chatelier test began to give trouble.

As an instance of the unreliability of the Le Chatelier test, a friend had sent them some clay from Australia, and asked them to sample this clay, and see whether it was fit for cement making. He was not prepared to say exactly the composition of that clay, but at the same time it looked very good, somewhat high in silica. They mixed this up with their own chalk and burnt it in the ordinary sample kiln, such as a great number of the manufacturers here probably used, and tested it; there was not enough of it to make tensile or other experiments, but there was enough to make a pat for the boiling Le Chatelier tests. The pat after boiling showed no curvature, but was absolutely brittle, and could be broken up with the greatest ease, the result of the Le Chatelier ; we could hardly measure the amount of expansion that occurred.

He had always found that the Le Chatelier test was a very useful one as an indication for the manufacturer, but was no guide as to the value of cement, and only gave a perfectly false impression to the users, as they did not really understand what it meant. The real test for the soundness of cement was the pat immersed in water for 28 days, after which time it should show no signs of curvature or flying, and should be quite smooth and sharp. The Le Chatelier test was an accelerated one, and as such, should not condemn a cement if it were shown to be otherwise sound.

MR. BUTLER.

The Lecturer's Replies. Mr. Butler prefaced his reply by expressing his thanks for the favourable reception given to his paper, and his gratification at the excellent discussion it had evoked. Replying first of all to the Chairman's remark, he said what he wanted was a test which would detect real, not imaginary, unsoundness. The primary function of a soundness test was to detect unsound cement—viz., cement which would cause expansion under practical working conditions. A test which condemned sound and unsound cement indiscriminately could not be a true test for soundness.

Mr. Bamber said it must be a bad cement, indeed, that would not stand the Faija test for soundness. He maintained in connection with the Faija test that what unsoundness the Faija test would not show was negligible. Regarding practical results, if a cement did not show any expansion in the Faija test, that cement would not show any expansion whatever in actual work. He was glad Mr. Bamber agreed with him that the Le Chatelier test should not be too rigidly interpreted ; when, as the discussion had shown, there were almost as many anomalies as orthodox results, it was a test that should be accepted with some reserve.

Mr. Nicol referred to boiling his test specimens for 48 hours. His own experience was that, if there was no expansion shown after six hours boiling or less, it would not show with longer boiling ; six hours was quite enough in the ordinary way to show all the expansion there was likely to be. Mr. Nicol also referred to the importance of the wet grinding during manufacture as having an important bearing on soundness, and he quite agreed with him, but Mr. Nicol rather seemed to confuse the two processes of wet grinding and dry grinding. He (the author) was fully aware that wet grinding was quite as important as dry grinding, but when Mr. Nicol referred to wet grinding he obviously confused it with dry grinding—*i.e.*, the reduction of the clinker and not wet grinding, which was reduction of the raw material. Mr. Nicol referred to his own accelerated tensile test, which was one day in air and two days in boiling water, and which he specified should show 30 per cent. higher results than one day in air and two days in cold water. The lecturer did not think any manufacturer would object to that, provided the cement would stand boiling water ; but, as he had said before, it had yet to be proved that because cement would not stand boiling water it was therefore unsound.

Mr. Tristram's remarks as regards his microscopic experiments were very interesting. He mentioned that he used a matrix with his grit, consisting of 16⅔ of fine cement to make it set. The lecturer found no difficulty in making the grit set in the Le Chatelier mould. Though soft, it set fairly well, although boiled out sometimes.

Mr. Watson suggested that many of the anomalies mentioned in the paper were capable of explanation, but he rather carefully avoided giving any. Mr. Watson's admission that some of the results he had himself obtained with the Le Chatelier test varied as the barometer had done in the last few days was rather significant, and tended to confirm the experience of a good many other operators.

Mr. Gadd reported his contention as to the increase of expansion on aeration, and said he could quote instances by scores. The lecturer could also, but only gave two or three in the paper just as examples.

Mr. Plaister referred to expansion in cold water. As they all knew, the old test for soundness used to be simply immersing a pat immediately after gauging in cold water, in the plunge pat, sometimes called "sudden death." That test was more or less a delusion. In the first place it was only neat cement that showed such cracks after immediate immersion. He had made many experiments with cubes and pats made up of sand and cement ; when they were plunged into water immediately, they showed no expansion, and if they did it was merely on the upper surface or skin, perhaps $\frac{1}{16}$ in. deep. It was purely surface cracking, and did not penetrate to any depth beneath the surface, therefore, in his opinion, it was negligible.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

ROOFING AT ST. ALOYSIUS CHURCH, GLASGOW.

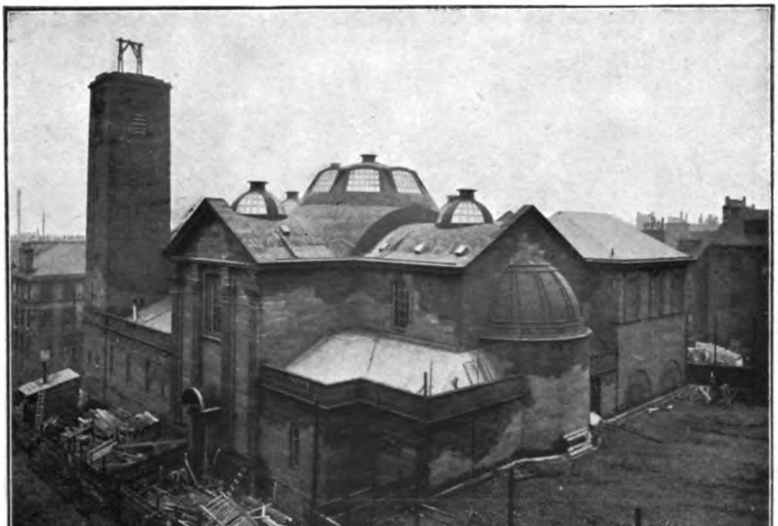
Reinforced concrete construction is gaining favour with architects for the construction of church roofs, the principal advantages being the practicability of constructing large barrel and domical roofs without unsightly trusses, tie rods, etc., and the low cost of upkeep.

An interesting example of this form of roof, and one of the first to be constructed throughout of reinforced concrete, is that of St. Aloysius Roman Catholic Church, Glasgow.

The reinforced concrete work was carried out by the Expanded Metal Company, Limited, of London and West Hartlepool (who are represented in Scotland by Mr. J. Monkhouse Cartmell, of 69 Buchanan Street, Glasgow), to the general designs and under the supervision of the architect, Mr. Chas. J. Menart, of Glasgow.

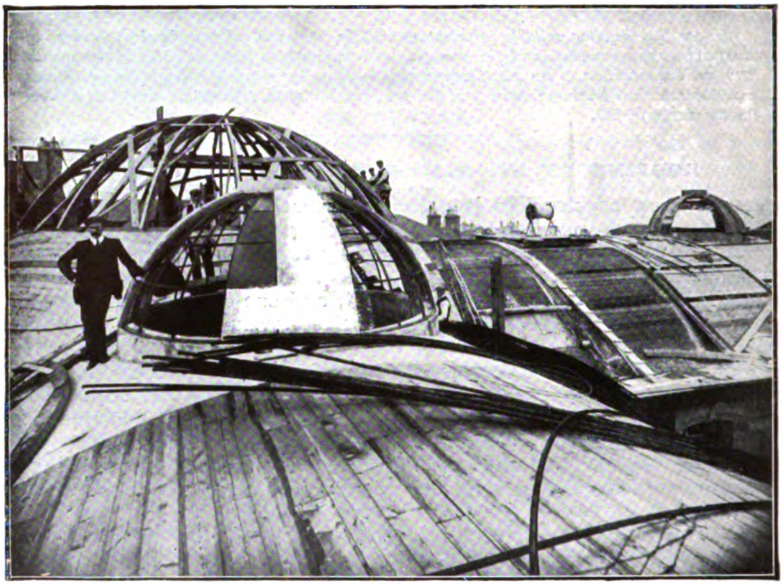
In plan, the church is of the usual cruciform shape, and the building is faced with red freestone in the classic style, the reinforced concrete roof work being carried on the main walls.

The roofs over the nave, transepts, and apse are in the form of semicircular arches, the nave roof having a clear span of 44 ft. 6 in., and a length of 65 ft. The nave roof is supported on arch ribs, reinforced in such a manner as to take the whole of the stress due to thrust without putting any thrust on the side walls, where the load is vertical; the ribs carry a $4\frac{1}{2}$-in. slab forming the roof covering, this slab being reinforced with Expanded Steel. There are two 4-light cupolas in this roof, which act also as ventilators.

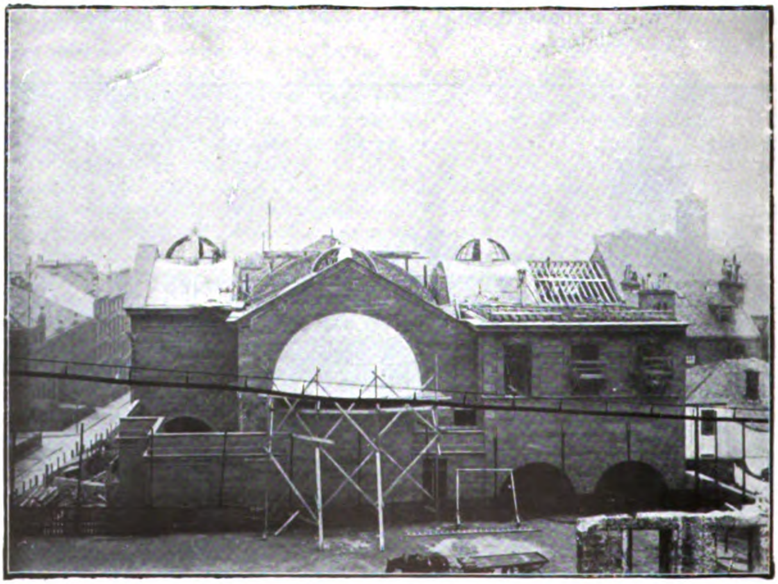


Expanded steel-concrete roofing.
St. Aloysius Church, Glasgow.

The roofs over the transepts and apse are of somewhat similar construction, but of smaller span. Three of the main arches, carrying the large central dome, are of brickwork; the central dome, which is 44 ft. by 34 ft. 3 in. on plan, has a radius of



Temporary timbering and reinforced concrete work in progress.



Reinforced concrete work nearing completion.
ST. ALOYSIUS CHURCH, GLASGOW.

29 ft. 6 in. for the first portion, and a radius of 21 ft. for the upper portion or dome proper; there are eight large lights in this dome. The concrete in the dome is

generally 9 in. thick throughout, reinforced with expanded steel, and circumferential round steel rod rings.

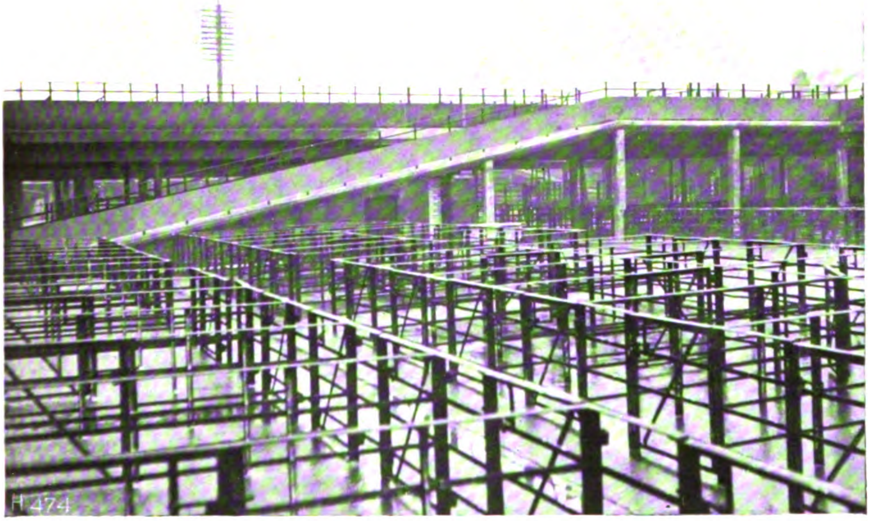
The sashes in all the roof lights are of wrought iron secured to the concrete, and the roof is covered with asphalt.

The interior will eventually be finished in a decorative style, for which reason its surface was left fairly rough with the object of forming a "key" for plaster or mosaic.

THE NEW REINFORCED CONCRETE GALLERIES AT HULL CATTLE MARKET.

The adaptability of reinforced concrete is perhaps nowhere better illustrated than in the new galleries at the Hull Cattle Market. From the photographs and drawings illustrated, it will be seen that it has been successfully used in the various units of the constructions, including foundations, columns, beams, cantilevers, floor decking, bridges, and screen walls. In none of the parts are the dimensions excessive or in any way displeasing to the eye; in fact, when compared with the old galleries, which are constructed of concrete arches between rolled steel joists supported on cast iron columns, the advantage of appearance certainly rests with the new galleries.

No. 1 Gallery is 106 ft. long and has an average width of 42 ft. No. 2 Gallery is 137 ft. by 21 ft., and No. 3 Gallery 142 ft. by 21 ft.



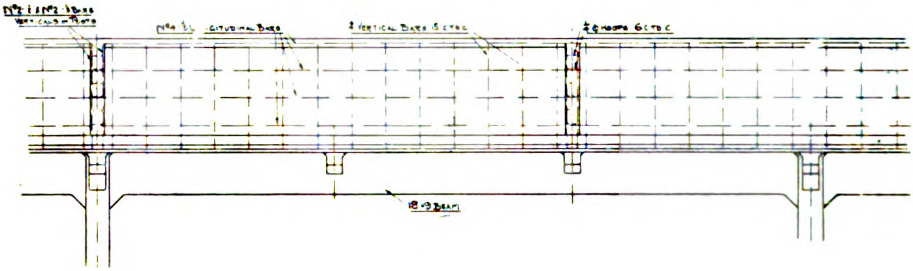
Slope to new Galleries.
Hull Cattle Market.

The most interesting features of No. 1 Gallery are undoubtedly the large columns and cantilevers supporting the centre floor panels, shown on page 289. It was desired to use the space beneath this gallery for two large cattle pounds, and the arrangement of a central column with cantilevers supporting the points of intersection of the longitudinal and cross-beams of the gallery was adopted as the arrangement which gave the greatest clear space. The drawing of one of these columns clearly shows the construction and also the disposition of the steel. The close hooping of the column and cantilevers indicates the high duty which was successfully imposed on them.

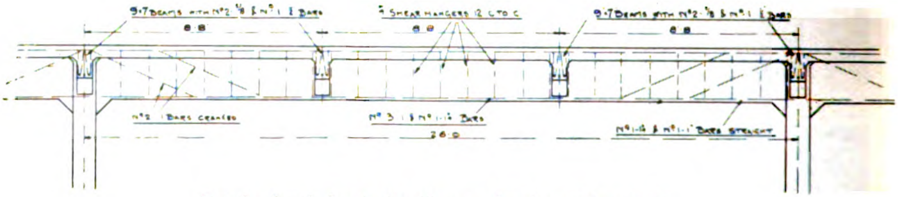
The designs of Galleries Nos. 2 and 3 were somewhat similar, the main difference being the spacing of the columns laterally. This resulted in a difference in length of the cantilever beams supporting the screen walls, which can readily be observed from the illustration.

The official testing took place on December 31st last, and consisted of loading three bays of Galleries Nos. 1 and 3 with bags of shingle to a weight of 200 lbs. per sq. ft. This load was left in position on both galleries for 15 hours before the deflection was measured.

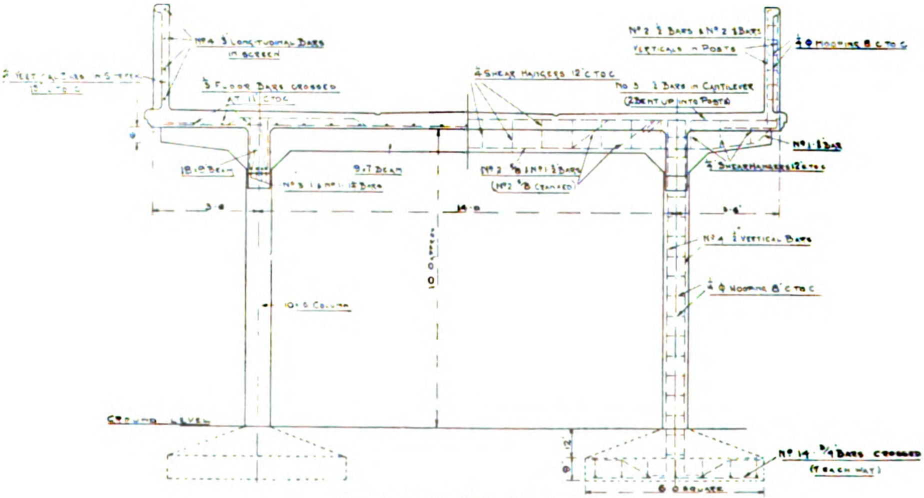
The greatest span of Gallery No. 1 was 13 ft. 3 in., and the maximum deflection registered was 0·021 in., equal to $\frac{1}{7956}$ of the span.



Details of screens, showing reinforcement.
Nos. 2 and 3 Galleries.

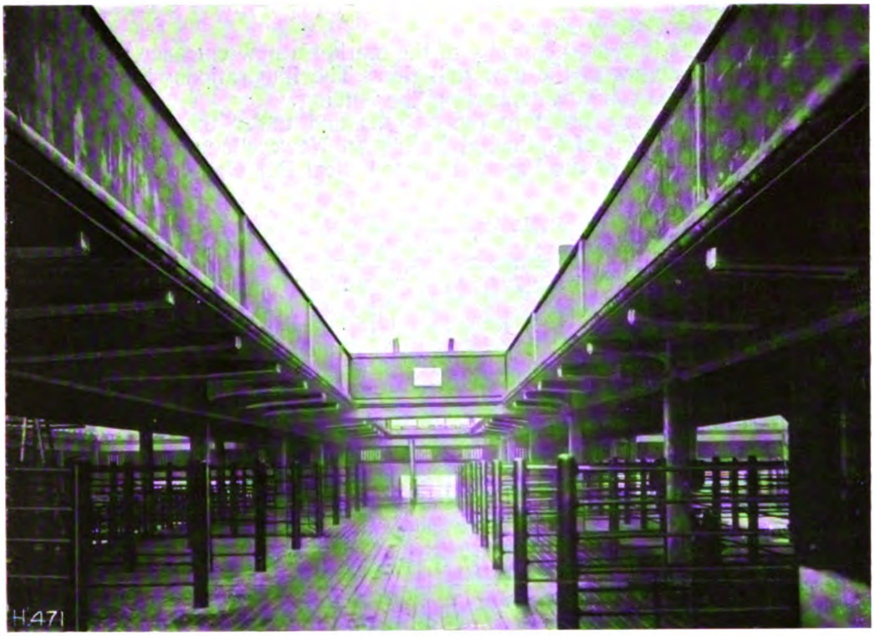

9.7 Beams with No 2 ⅞ & No 1 ⅞ Bars
⅜ Shear hangers 12 c to c
6.8
6.8
6.8
26.0

Details of main longitudinal beams, showing reinforcement.

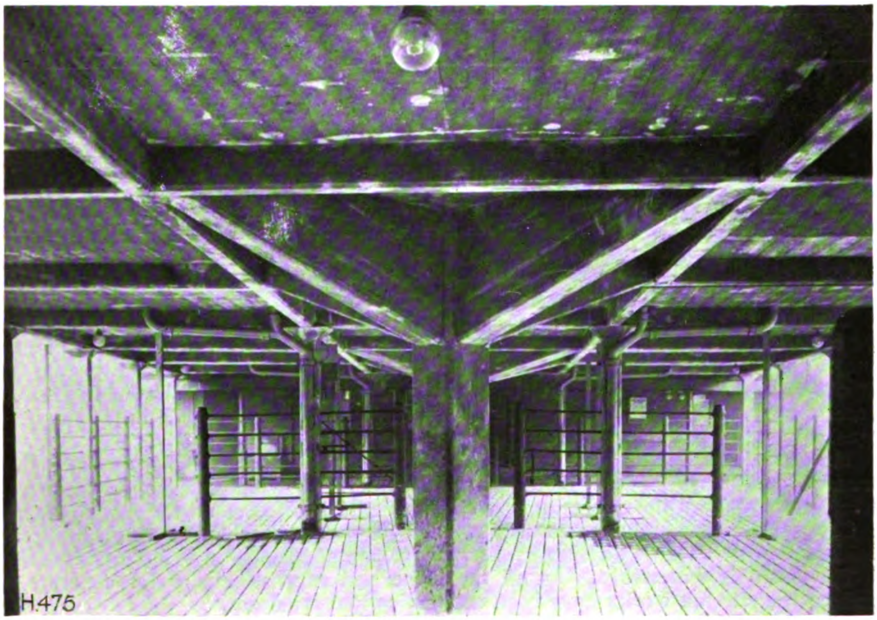


Detail section of No. 3 Gallery.
HULL CATTLE MARKET.

The maximum span of Gallery No. 3 was 25 ft., the permissible deflection 0·5 in., and the maximum registered deflection 0·10 in., being $\frac{1}{306}$ of the span.



View of Nos. 2 and 3 Galleries.

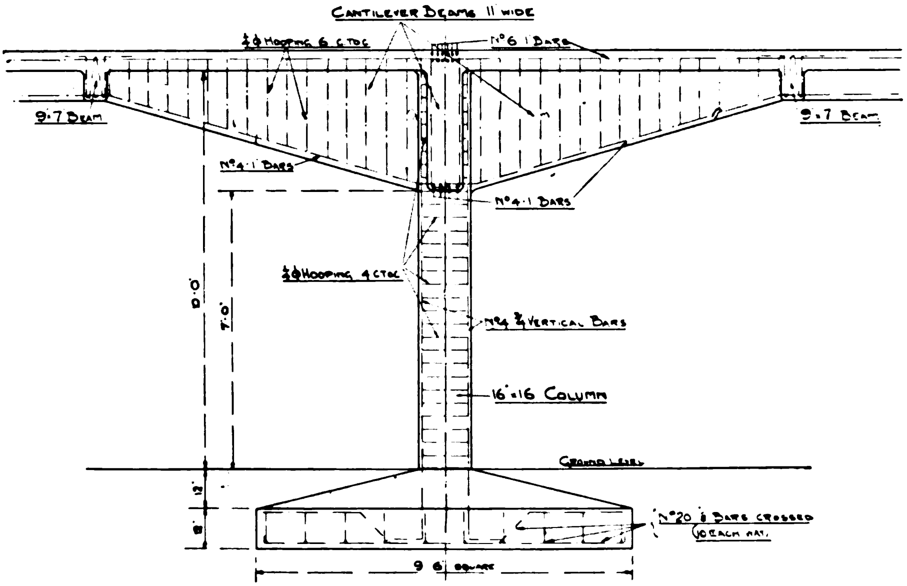


View under No. 1 Gallery.
HULL CATTLE MARKET.

As these tests were considered most satisfactory the engineer decided that it was not necessary to test Gallery No. 2.

To cope with the increased capacity of the market a new entrance and slope were constructed to give access to the new galleries. The illustrations show this part of the works and also the columns supporting the landing.

The works were constructed to the designs and under the supervision of the British Concrete-Steel Co., of Cathedral Buildings, Newcastle-upon-Tyne. The reinforcement used was that of the Patent Indented Steel Bar Co., Ltd.



Detail of column and cantilever beams under No. 1 Gallery.

Hull Cattle Market.

NEW CANAL BASIN AT BRADFORD.

The canal basin in our illustration is an arm of the Leeds and Liverpool Canal, situated at Strangford, on the Esholt Estate, within the City of Bradford, and adjoins the large and important sludge disposal works which are now being erected.

Concrete construction was employed throughout in the walls of this basin and also in the bottoms, which were made 6 in. thick.

The basin is 133 ft. 6 in. long, 45 ft. wide, and the bottom is formed in two equal bays of different depths. The depth of water in the back bay is 6 ft., and that in the front bay at the entrance is 8 ft. 6 in. This extra depth of 2 ft. 6 in. over the front half of the basin is important, and is provided for the reception of silt, which is found to collect somewhat rapidly. The basin is capable of accommodating four of the largest boats in use on the canal at the present time.

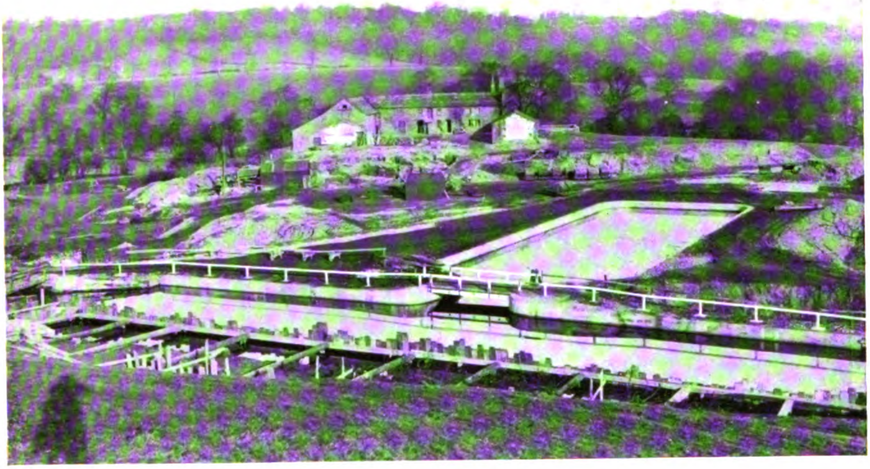
The canal itself has been widened and deepened on both sides at the basin entrance. These works have been carried on, without hindrance to ordinary canal traffic, by means of timber sheeting driven into the bed of the canal to form cofferdams.

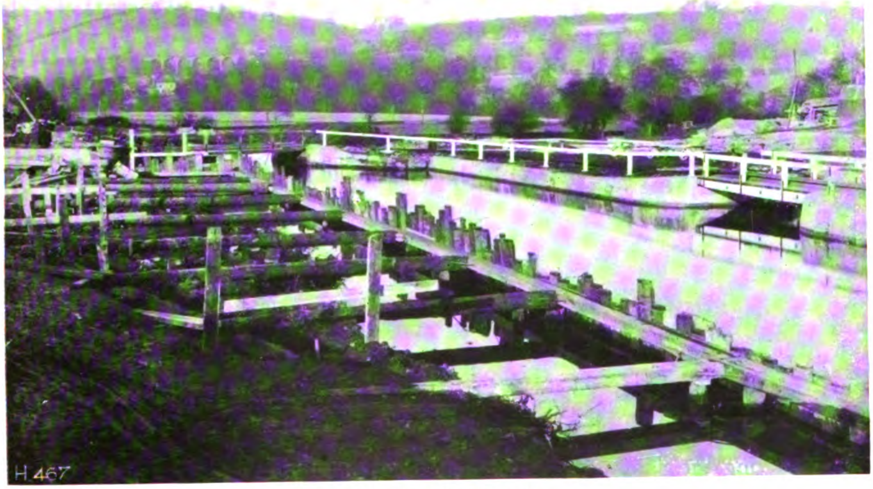
Concrete face walls have been constructed for a considerable length on both sides, providing further accommodation for four canal boats.

The basin is watertight. As all the stone and sand necessary for concrete was found on the site the works have been economically carried out.

The works were commenced early in June last. The basin was filled with water on October 22nd, and was formally opened for traffic on January 4th.

The works, which included a considerable amount of excavation and filling for the formation of yards around the dock and a length of new roadway, were carried out by administration, the chief engineer being Mr. Joseph Garfield, Assoc.M.Inst.C.E., and the resident engineer, Mr. Wontner-Smith, Assoc.M.Inst.C.E.



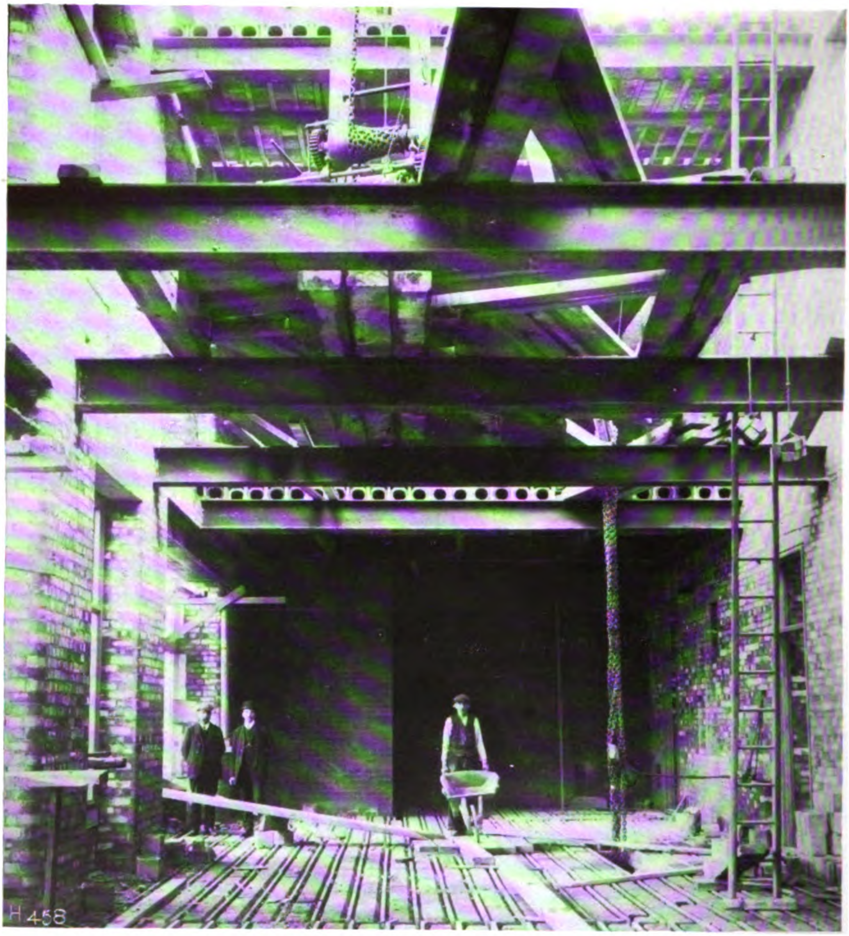


CANAL BASIN AT BRADFORD.

FLOORING AT THE TECHNICAL INSTITUTE, BELFAST.

THE illustration herewith is of the flooring at the Technical Institute, Belfast. The spans in this instance were 20 ft. in the clear, and they are now carrying a working load of 2 cwt.

The construction consists of a series of concrete webs, which are reinforced with a patented section of steel bar. Small tubes are fitted between the webs and a thin layer of concrete laid on the top.



VIEW OF FLOORING.

Our illustration shows how this system of flooring can be laid without centering, and also demonstrates the freedom of site given to the builder for the progress of his work.

The flooring throughout this building was laid by the Armoured Tubular Flooring Co., of Victoria Street, S.W.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

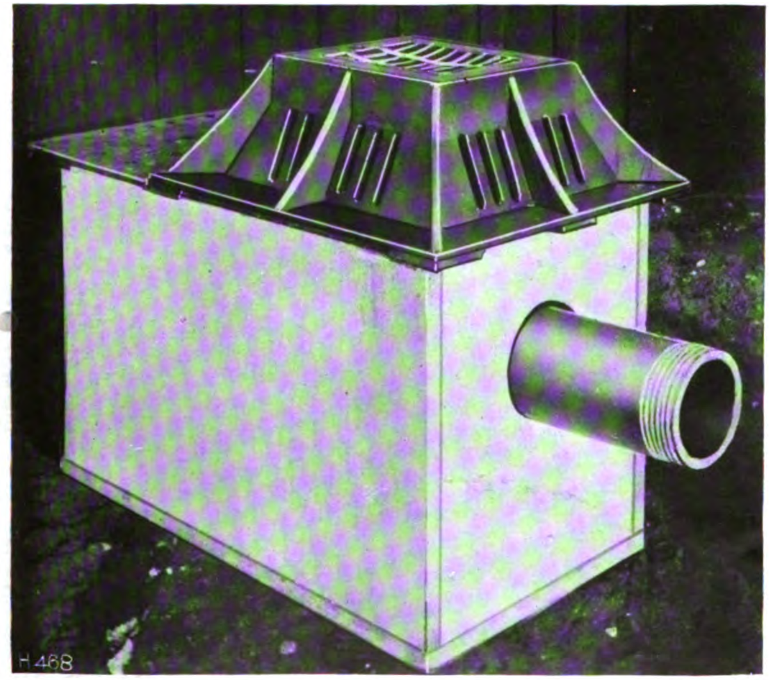
REINFORCED CONCRETE MANHOLE.

THE accompanying illustrations show a reinforced concrete manhole, used in draining the main line of the Midland and Great Northern Joint Railway.

It is necessary, at every three or four chains, to place a manhole, so that the pipes can be inspected and cleaned out if necessary, and in the ordinary way this means sending a bricklayer perhaps five miles from a station and carting bricks and cement some distance.

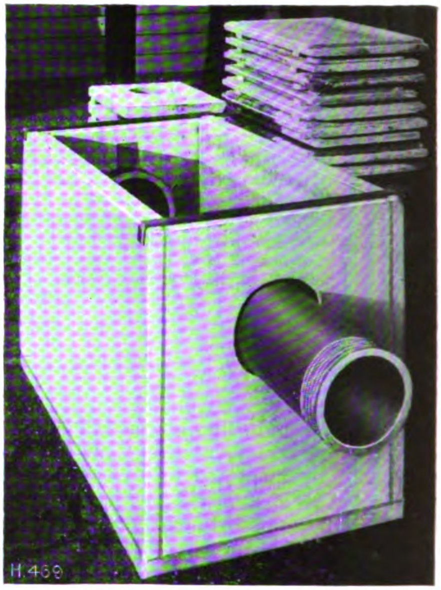
The great advantage, therefore, of the reinforced concrete manhole described here is that it is made at the depôt, and can be put in without skilled labour by the ordinary draining gang.

The illustration below shows the manhole with the drainage gate on the top, which was designed by Mr. Alexander Ross, M.Inst.C.E., and used on the Great Northern Railway.



REINFORCED CONCRETE MANHOLE, SHOWING DRAINAGE GATE.

A REINFORCED CONCRETE COAL POCKET.

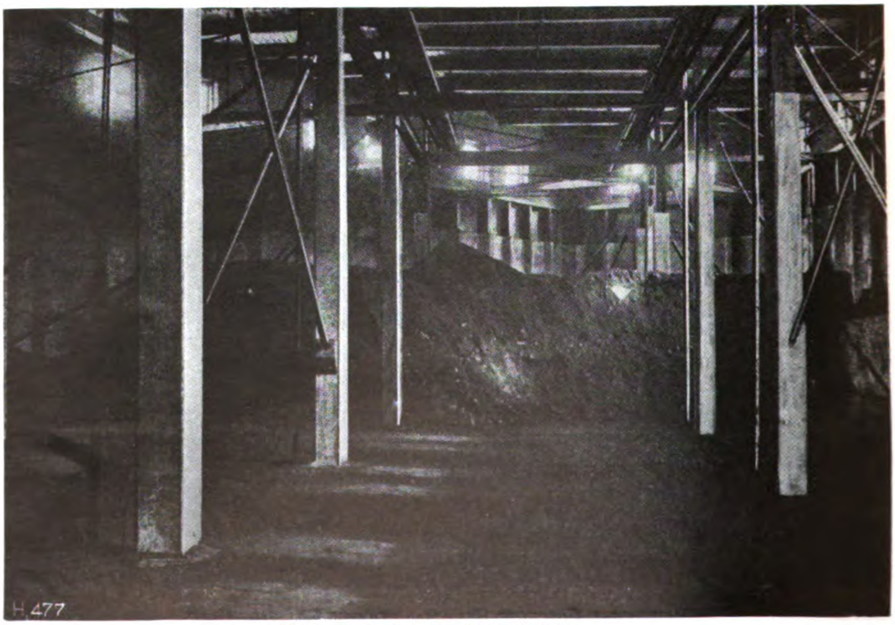


Reinforced Concrete Manhole.

A coal pocket, embodying a rather unusual combination of brick and reinforced concrete construction, has recently been built for the L. S. Starrett Co., Athol, Mass., from designs by Charles T. Main, mill engineer and architect, of Boston.

In plan, the pocket is triangular, being 150 ft. by 109 ft., and about 30 ft. high. The walls are of brick, within which is built a concrete steel shell or lining. This relieves the former of the pressure of the coal, and at the same time serves as a protection for the brick wall. This lining is built directly against the brick walls, except at one corner, thus saving the cost of form work on the outer side.

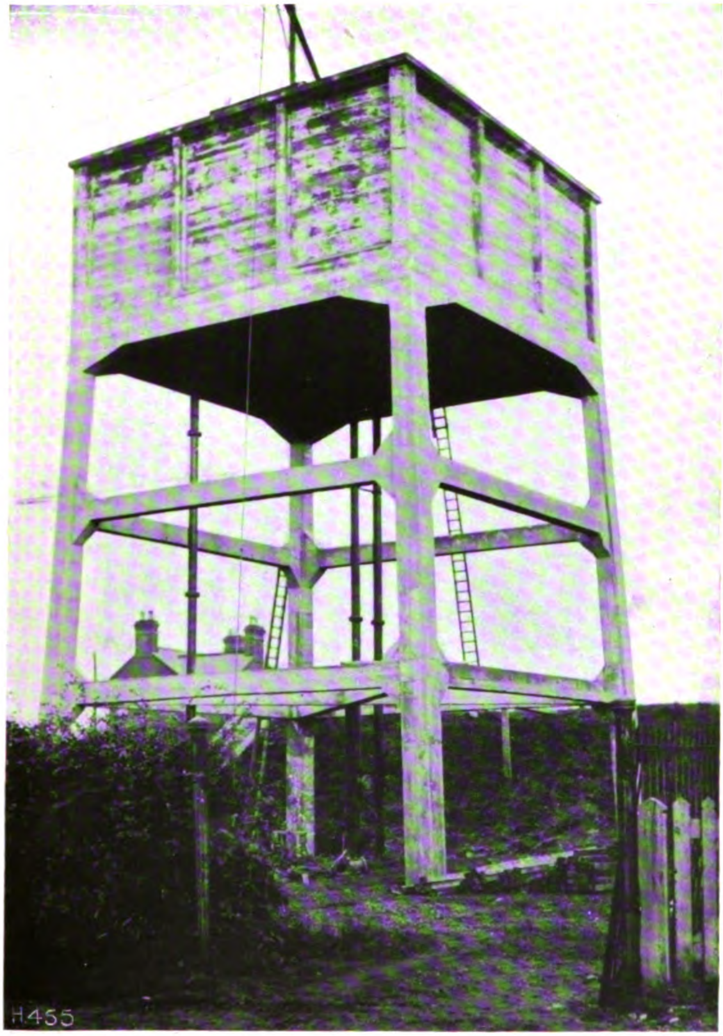
The brick walls are 12 in. thick, with integral pilasters 20 in. in thickness. The concrete steel lining is carried up 20 ft. Two 15 in. by 33 lb. channels, back to back, spaced about 23 ft. apart and embedded in the concrete except on the boiler-room side, connect with the longitudinal and transverse channel braces overhead, thus binding the parts subjected to the coal pressure firmly together. On the boiler-room side of the coal pocket the above-mentioned vertical channels are set into the brick walls. Between these are vertical "I" beams varying in size from 7 in., 15 lb., to 12 in., 31·5 lb. Between the latter are concrete slabs $5\frac{1}{2}$ in. thick, reinforced with both horizontal and vertical steel wires. The concrete around the wall channels and "I" beams is held in place by metal lath reinforcing. All steel work is protected by at least 2 in. of concrete.



View of interior of Coal Pocket.

Two rows of steel columns, spaced 18 ft. apart in a transverse direction and 23 ft. 6 in. apart longitudinally, connect with the overhead channel braces and support the longitudinal roof beams. These columns, of square section, are made up of angles latticed to form an "I" beam section, and are encased in concrete up to a height of 15 ft. The concrete at the corners of each column is reinforced by steel rods.

The roof is supported by the brick walls and columns, the concrete lining carrying none of the weight. Diagonal steel tie rod bracing, with turn buckles, is used in conjunction with the columns, and connection is made thereto by clevis nuts, wired and covered with 2 in. of concrete. Up to a height of 15 ft. these rods are encased in boiler tubes with cement between. The floor is of concrete, 9 in. thick, finished with trowelled surface. We are indebted to *The Cement Age* for our illustration.

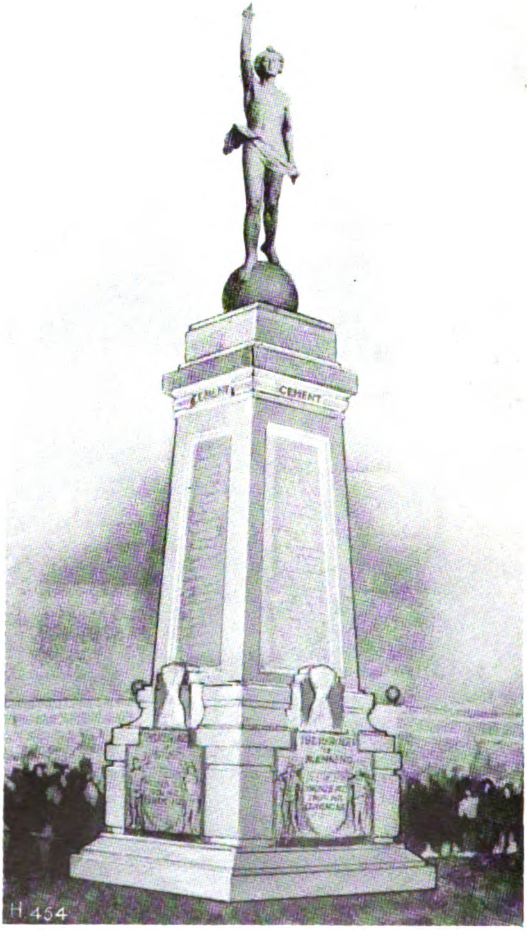


Water Tower at Great Marlow.

WATER TOWER AT GREAT MARLOW.

This water tower was constructed in reinforced concrete on the Hennebique system by Messrs. Holloway Bros. (London), Ltd., for the Great Marlow Water Company, and has a capacity of 30,000 gallons.

The reservoir at the top is square on plan with sides 5 in. thick, 20 ft. long by 9 ft. 6 in. high (inside measurements), while the top level, of cornice beam, is 40 ft. 6 in. above the ground level. It is carried by four corner columns, square, in section, each 14 in. by 14 in., and reinforced with four bars linked together in the usual way. The feet of the column terminate in foundation slabs, 6 ft. square, 20 in. deep, reinforced with $\frac{7}{16}$-in. diameter bars laid parallel to the sides and crossing each other. These slabs were connected to each other by tie beams 14 in. by 10 in., the whole foundation being 3 ft. 6 in. below the level of the ground, and firmly braced together.

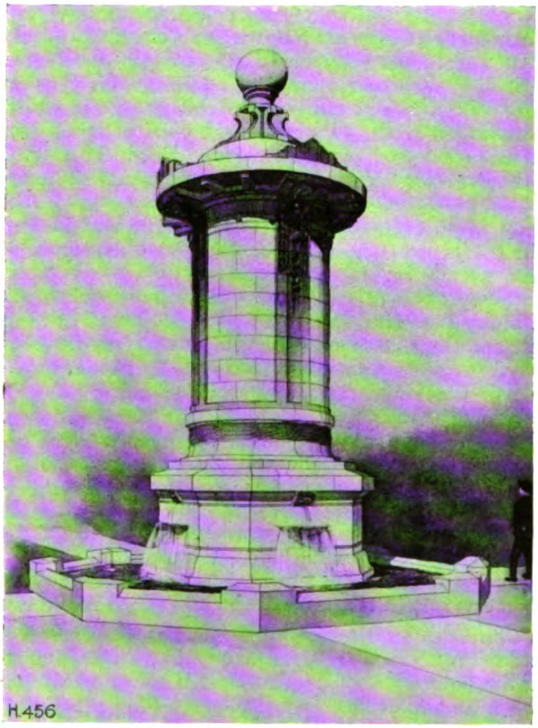


Decorative Centrepiece erected at the Annual Cement Show in Chicago.

The columns are braced at heights of 10 ft. The lower bracing consists of four beams, 14 in. by 10 in., running between the columns and parallel to the sides, and two beams running diagonally between opposite columns. At the higher level the diagonal bracing was omitted. The columns were continued up the sides of the reservoir to form corner counterforts, while between them, at the level of the bottom of the tank, were four main beams 12 in. wide by 18 in. deep, carrying the outside walls of the tank and also carrying four subsidiary beams which, in their turn, carry the floor of the tank. These subsidiary beams were 7 in. wide by 15 in. deep, and the floor 5 in. thick. The side walls, 5 in. thick, were each further strengthened by two counterforts, 5 in. by 6½ in., rigidly held at their tops by the cornice beam previously referred to, and were thus constructed as vertical floors. The side walls were also braced by four beams 7 in. wide 12 in. deep, each connecting opposite walls. The reinforcement in the walls consisted mainly of $\frac{3}{8}$-in. vertical bars and $\frac{7}{16}$-in. horizontal ones.

DECORATIVE CENTREPIECE FOR THE CHICAGO CEMENT SHOW.

A competition was organised in America for the design for an ornamental centrepiece to be erected at the Third Annual Cement Show, held at Chicago in February last, and a large number of most interesting and attractive designs were submitted.



DESIGN WHICH OBTAINED THE SECOND PRIZE.

The centrepiece was to be of either plain or reinforced concrete, concrete blocks or cement plaster, and it could be finished in any manner which would produce a pleasing effect.

The design chosen for the first prize was composed of a gigantic pedestal ornamented with figures in relief supporting a shaft some 35 ft. high. The top figure was re-designed, that which was eventually erected representing a powerful youth, and is typical of the cement industry. The four sides of the base are decorated with plaques, the upper part being a shield and the lower being a design representing the four ages of mankind—the Stone, Bronze, Iron, and Cement Ages.

We also show an illustration of the design which obtained the second prize, and which represents a very attractive fountain, 25 ft. in height.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Tests of the Reinforced Concrete Slipway at Ackergill.—Referring to the account of the above construction in our February issue, certain tests have been made on the various members of this structure, and the results, which were supplied to us by Mr. B. J. Allison, of Wick, N.B., who was in charge of the work for the contractor, have been highly satisfactory.

Several beams were selected by the Resident Engineer (Mr. H. Tripp) as being representative of their respective types, and these were subjected to the following loads :

(1) A 13-in. by 13-in. (octagonal) horizontal strut was loaded under a weight of $2\frac{1}{2}$ tons placed in the centre, the distance between the supports being 19 ft. The deflection recorded was $\frac{1}{16}$ in.

(2) A complete bay of open cross-framed decking was loaded as follows : 20 tons were distributed along the centre keel beam (20 in. by 18 in.), the span being 19 ft. between supports, and the side, $17\frac{1}{2}$ in. by 9 in., and cross beams, 9 in. by 6 in., were also loaded to 1 cwt. per superficial foot (of slipway). In addition, the gangway steps, carried on cantilever brackets at side, were also loaded to $1\frac{1}{2}$ cwt. per super foot, the total load on the bay being about 32 tons. In the case of the centre beam (20 in. by 18 in) a deflection of less than $\frac{1}{16}$ in. was registered. No deflection was recorded on the side beams and steps.

In each case, where any deflection was recorded under the test load, the beam returned to its original alignment when the load was removed.

As the permissible deflection on the given span was $\frac{3}{8}$ in., the results obtained are an excellent proof of the strength and rigidity of this form of construction.

In view of the very satisfactory result of the tests made, certain others of a minor nature were not considered necessary.

Transport of Concrete in Pipes.—Some interesting experiments made last year have demonstrated the practicability of transporting concrete and mortar from the mixing machine to the point of application through tubes of small diameter by the aid of compressed air. With air at the pressure of 50 lb. per square inch it was found possible to transport concrete mixed in the proportions of 1 :3 :5 for distances up to 400 ft. in a pipe of only 4-in. diameter, the material coming from the further end of the conduit in a perfect state of mixture and at such velocity as to necessitate special provision for its reception. The apparatus at the feed end was of simple character, comprising a closed receptacle, provided with a valve for the admission of concrete, in communication with the compressed air pipe and connected with the transmission pipe line by a funnel-shaped outlet. The chief thing to be guarded against in this method of handling concrete is the clogging of the conduit, but it is probable that the rapidity of transmission would obviate any tendency of the kind. The idea certainly deserves a trial on some important building contract where large quantities of concrete have to be delivered from the mixer to all parts of the site. One great advantage would be the avoidance of delays, which are likely to cause partial segregation of the mixture and to encourage partial setting of the cement. The question of economical working, of course, comes in, and must be decided by experience.—(*The Builder.*)

Building a Concrete Cistern.—An improvement in the method of constructing a cement cistern, over the plan ordinarily recommended, was recently observed by a contemporary on an Ontario farm. The method usually adopted of building an upright circular wall and covering-arch at one operation involves the taking out through the manhole of all the curbing as well as the timbers supporting the arch. In this case, after the circular wall had been finished to the top of the curbing, it was allowed time to set sufficiently, and then the curbing was all taken out. The supporting frame for cement arched cover was made by cutting six or eight short rafters, with slight heel projection, resting on inner edge of perpendicular surrounding wall, and tops meeting over centre of cistern. A wooden box for a manhole was set in position, the remaining space on the rafters boarded over, and the cement covering spread on the desired thickness and shape. When safe to do so, in about a week, the roof structure was easily removed from the inside, only a very few nails having been used.

Tests on the Permeability of Concrete.—The University of Wisconsin has issued a bulletin on the above subject by Professor Francis Michael McCullough, Instructor in Mechanics. The bulletin comprises a report of a series of permeability tests made in the laboratory for testing materials at the University of Wisconsin during the summer and autumn of 1908. The object of the tests was to determine the efficiency of some of the commercial compounds used for the waterproofing of concrete.

Tests were made on fourteen compounds, each compound being subjected ordinarily to pressures of approximately 20 lbs./in.^{2} and 40 lbs./in.^{2} The duration of the test was usually three days, and a record was kept of the amount of water entering the concrete.

In order to ascertain the effect on the strength of concrete of the compounds which are added to the body of the concrete, compression specimens were made. Three of the compounds were tested in this manner, the specimens being broken at the ages of approximately one, two, and ten months.

Among other conclusions, it is stated that, unless extreme care is taken in proportioning, it is necessary that some form of waterproofing be used for a 1 :3 :5 concrete for pressures from 20 lbs./in.^{2} to 40 lbs./in.^{2}

For nearly all specimens the rate of flow decreased rapidly with time. This was especially marked in the case of the mortar coatings, and was due in part to their dry condition.

Placing Concrete under Water.—There is undoubtedly a strong prejudice in the engineering profession against laying concrete under water. Millions of pounds are spent every year, according to *The Engineering Record*, on coffer-dams and caissons, in order to lay foundation concrete in the dry. Notwithstanding this, it is entirely possible to lay concrete under water which will be as sound and solid as the best concrete laid in the open air. In the construction of the Detroit Tunnel a large amount of concrete was deposited around the submerged steel tubes. A core from this concrete, which had been taken to determine its quality, was recently examined. The core was as sound and solid as a natural conglomerate rock. Tests of samples of this concrete have shown a strength as high as, or higher than, the best specimens of concrete laid in the open air. This concrete is deposited through a tremie, or long tube with its upper end in the open air a considerable distance above the water surface, and its lower end at the point where the concrete is to be laid. Concrete put in place by such methods is forced in under a pressure far greater than is possible with any hand ramming ever used. There is no space for voids and no opportunity for the entrance of air. Furthermore, the concrete is never dried out in the process of hardening, and has always available all the water that it needs for its final set. These reasons are all of importance in explaining the high quality of concrete laid in this way.

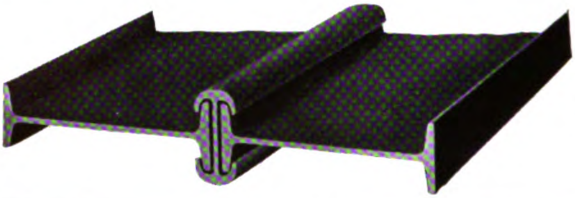
At the recent convention of the National Association of Cement Users, Mr. Olaf Hoff also referred to the method of using tremies for depositing concrete under water, and gave what he considered the reasons for its success. First, the exterior of the tunnel tubes is divided into compartments or pockets by means of the longitudinal sheathing and the diaphragms. This produced still water, which is absolutely necessary for laying concrete under water, and permitted the filling of one pocket at a time with a monolothic mass of concrete. This arrangement further limited the lateral flow of the concrete, as it emerged from the tremie, to the confines of the pocket and reduced the washing out of cement to a minimum. In fact, the loss

UNIVERSAL JOIST STEEL SHEET PILING

Drives Freely.

Pulls Freely.

Can be used repeatedly.



Practically Watertight.

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High Salvage Value.

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BELFAST HARBOUR BOARD
GREAT WESTERN COLLIERY
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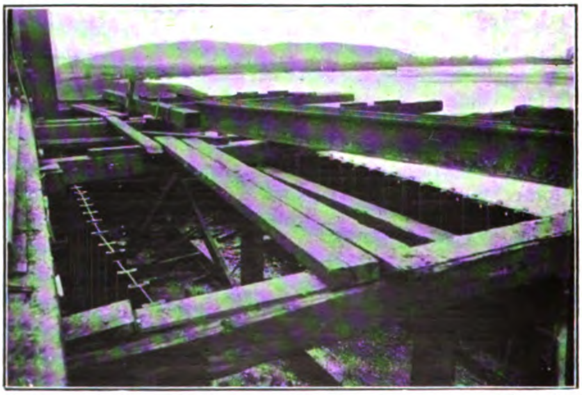
ALL TYPES OF PILE DRIVING PLANT

SEND FOR CATALOGUE.



Photograph shows 15-in. by 43-lb. Piling in use on one of twelve Cofferdams being constructed for a Viaduct over the River Loughor by Messrs. Walter Scott & Middleton, Ltd. The Piles will be used six times.

TELEGRAMS—"GRAMERCY, LONDON."

TELEPHONES—
P.O. 1414 Central.
Nat. 1414 Avenue.

THE BRITISH STEEL PILING CO.
DOCK HOUSE, BILLITER STREET,
LONDON, E.C.

of cement appeared to be negligible. Second, the equipment was very complete, and the rig for handling the tremie pipes was especially quick acting, so that the pipes could be manipulated promptly as occasion required. Third, the concrete was mixed so wet that it would flow readily in the tremies. Fourth, the flow was controlled by keeping the mouth of the tremie buried at all times in the concrete to a sufficient depth to keep it sealed and prevent water from rushing in from the outside.

Municipal and Health Exhibition.—The second Municipal and Health Exhibition is announced to be held at the Royal Agricultural Hall, Islington, from May 7 to May 14. Such exhibitions are designed to make known the most efficient methods of street cleansing, street paving, the economic utilisation of refuse, public lighting, traction, the housing of the working-classes, and the construction of public buildings. The forthcoming exhibition will be under the patronage of a large number of lord lieutenants, lord mayors, and mayors; and an advisory council has been formed of municipal surveyors and engineers throughout the United Kingdom, with Professor Henry Adams as their Chairman.

The promoters of the exhibition hope to achieve two objects—(1) To interest and instruct municipal officials; and (2) to educate the public in the municipal services upon which the rates are expended. The exhibits will be divided into two main classes—public works and internal administration—and they will illustrate the details of the construction of town halls, public libraries, hospitals, schools, asylums, workmen's dwellings, bridges, and markets, and the laying out of public parks and cemeteries. There will also be exhibits in connection with public sanitation, traffic (road and river), municipal ambulances, municipal telephones, smoke abatement, water supply, and fire prevention. The Incorporated Association of Municipal and County Engineers has arranged to hold a meeting at the exhibition, at which papers will be read upon topics suggested by the exhibits. It is proposed to give technical lectures in the afternoons and popular lectures in the evenings upon questions of local government, and facilities are to be sought to enable the municipal officials to visit public works in London.

Irish Road Congress.—An Irish Road Congress is to be held in Dublin in April next in connection with the Spring Agricultural Show of the Royal Dublin Society. It is proposed that at the same time as the Congress there shall be an exhibition of road making and repairing machinery and implements, and applications for space therein should be made to the Secretary of the Royal Dublin Society, Ball's Bridge, Dublin.

Among the subjects on which it is hoped that papers will be submitted to the Congress are: The maintenance of trunk roads; State contribution towards road maintenance; laws relating to opening roads, laying pipes, etc.; extraordinary traffic, light railways and tramways on roads; formation surface, foundations, drainage, and superstructure. Also bridge work and reinforced concrete construction, various qualities of road materials, direction posts, etc., dust nuisance, economy of even surface, etc. The Secretaries to the Congress are Mr. A. Keogh Nolan, 10 Leicester Street, Dublin, and Mr. R. H. Dorman, County Surveyor, Armagh, from either of whom lists of the committees, programmes of the Congresses, etc., may be obtained on application.

Resistance of Concrete to Gun Fire.—The resistance of concrete to gun fire was tested practically to some extent at Port Arthur, says *Engineering Record*, and different opinions have been expressed regarding the lessons to be drawn from the results there. In a general way, the objections to concrete have been based mainly on the claim that the effect of the impact against it was to crack such a large mass of material that the integrity of the structure was much weakened even beyond the immediate vicinity of the point of impact. Reinforced concrete has been suggested a number of times as a substitute for mass concrete in military works, in order to meet this objection, and some tests were recently conducted at Sandy Hook for the purpose of determining to what extent the reinforcement would limit the effect of the projectile. The results are of a confidential character, but it is understood that the success of the reinforcing rods in confining the shattering of the concrete to the immediate neighbourhood of the pathway of the shot through the mass was marked. While the steel did not appear to reduce greatly the absolute depth of penetration of the projectile, it localised the damage very satisfactorily, so long as the shells did not detonate after penetrating.

Reservoir at Low Biggins.—The Kirkby Lonsdale U.D.C. have adopted the Surveyor's alternative schemes for the construction of a storage reservoir and the necessary alteration of mains and services in order to improve the water supply to Low Biggins, the scheme providing a storage capacity of four days' supply being estimated to cost £100, and that for seven days' supply £140. The Council have resolved that tenders be invited for the work connected with the seven days' supply, the prices being obtained to show the respective cost of a concrete roof to the reservoir and of a corrugated, galvanised iron one with surrounding fencing.

TRADE ANNOUNCEMENTS, CATALOGUES, ETC.

W. J. Fraser & Co., Ltd., of 98 Commercial Road, London, E., send us an interesting booklet descriptive of the "Trump" concrete measuring and mixing machine, for which they are the Manufacturing Agents in Great Britain and the Colonies. The principal advantage claimed for the "Trump" over the ordinary mixing machine is that it can be set to give any particular proportion of cement, sand, and ballast required, and, when once set, is locked, so that the engineer or clerk of works knows that the concrete is being made in the *exact* proportions which he desires. The importance of uniform and continuous measuring is dwelt on, and the measuring device of this machine is described and illustrated in detail. The "Trump" portable concrete measuring and mixing machine is a self-contained outfit, and when equipped with the portable conveyors requires no erecting expenses. The concrete machine and the conveyors are hauled separately to the site of the work; one end of the conveyor is raised so as to rest upon the top of the concrete machine, one chain is connected up, and it is ready to start. The source of power is permanently mounted on the same frame, and may be gas, electric or steam.

The (U.K.) Winget Concrete Machine Co., Ltd., of Northumberland Street, Newcastle-on-Tyne, have appointed Mr. T. Percival Chubb, of Bowley Street, London, E., as their sole Agent for London and the Home Counties for the sale of their well-known "Winget" concrete block-making machine and their "Express" concrete mixers.

A NEW PROCESS

FOR FIXING IN REINFORCED CONCRETE FLOORS, ROOFS & WALLS, WHETHER STRAIGHT OR CURVED, BY A SIMPLE METHOD, WITHOUT THE USE OF SHUTTERING

This process considerably cheapens the cost of the concrete construction, and is indispensable in districts where there is a scarcity of timber.

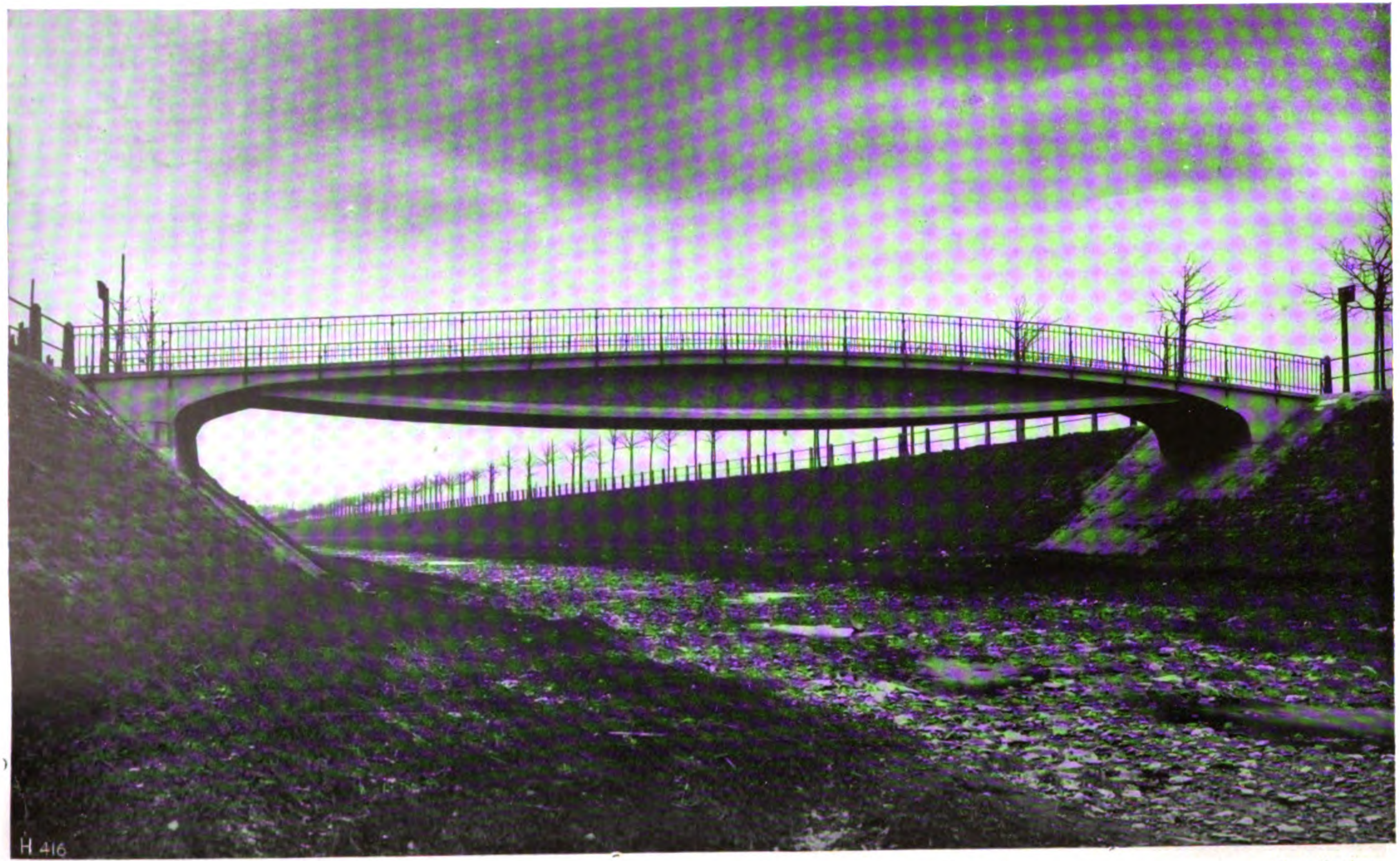
ALSO

NEW HOLLOW CONCRETE FLOORS AND NEW T-BEAM FLOORS

Hollow Concrete Floors, filled with insulating material

Cheaper than ordinary concrete or T-beam floors. Further particulars from

JOH. VIRCK, Architect, Malchow, Mecklenburg, Germany.



Reinforced Concrete Bridge over the Weisseritz at Cotta-Dresden.

Frontispiece
(Opp. Contents)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 5. LONDON, MAY, 1910.

EDITORIAL NOTES.

REGULATIONS FOR REINFORCED CONCRETE.

THE article on "Regulations for Reinforced Concrete Buildings in London," which appeared in our last number, has led to a considerable amount of correspondence reaching us on the subject of public control.

The pressure on our space prevents our giving the correspondence the publicity we should like, and we have had to limit ourselves to publishing two letters, one from a well-known civil engineer, the other from the manager of a representative specialist firm.

The matter is one of great importance to the development of reinforced concrete in this country, for, as we have indicated on earlier occasions, we hold that the careful regulation of reinforced concrete would influence the sound development of this material, and prevent the set-back to be expected in the event of any serious accident occurring in the United Kingdom.

We take this opportunity of calling attention to the standard building regulations for reinforced concrete which have been suggested by the National Association of Cement Users of the United States at their recent convention in Chicago.

A copy of these regulations appears in this issue, and, coming as they do from those who really use the material, they are worthy of careful attention. We are glad to observe that the American cement users have formulated their own views in such a precise manner.

To all who are interested in the subject of regulations for reinforced concrete we cannot, however, do better than refer them to the article on "Regulations and Recommendations for the Use of Reinforced Concrete as Published in Various Countries," which appeared in our Journal in July, 1908, and which gave a very compact summary of the rules and regulations that had been issued by the various countries, all the clauses being tabulated under leading headings, which makes it very handy for reference purposes.

THE CONCRETE INSTITUTE—VISIT TO PARIS.

The Concrete Institute, which has been giving considerable attention to the question of the rusting of steel embedded in concrete, is making careful inquiry as to some of the older examples of reinforced concrete, or their equivalent, in this country and abroad.

In connection with these investigations it is of interest to us to learn that the Science Committee of the Institute has extended its personal investigation to the Continent, and that a visit has lately been paid by several of the members of the Institute to France with a view to obtaining knowledge of some of the earliest examples of reinforced concrete to ascertain the durability of this material.

France is obviously the home of reinforced concrete, and it is only fitting that Paris should be visited in connection with work of this kind.

A short account of the places visited is given under "Memoranda," in this number, but we hope to be able to publish more detailed particulars at a later date.

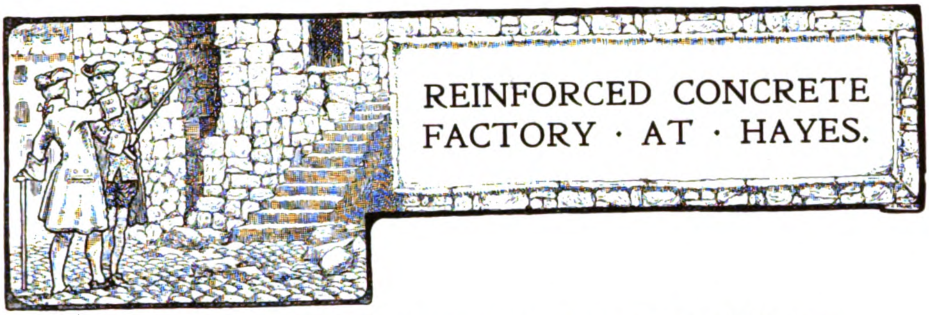
The following notice has been issued by the Institute to the Press :

> The deputation of members of the Concrete Institute have returned from Paris, where they have been making a special inquiry into the durability of reinforced concrete. For this purpose, visits were paid to about a dozen important structures in and near Paris, including bridges, culverts, tunnels, reservoirs and buildings, all of reinforced concrete. These were of various ages, the oldest being the roof of a large house constructed no less than fifty-eight years ago by the late M. Coignet, whom many consider to have been the first inventor of this material.
>
> The programme of visits was arranged by Professor Rabut, the Chief Engineer for New Works of the French State Railways. The deputation were specially invited to dine with the Association des Ingénieurs des Ponts et Chaussées. In the absence of the President, the visitors were received by M. Colson, Membre de Conseil de l'Etat, a former Inspector-General of this distinguished corps.
>
> The visitors were also hospitably entertained by the Chambre Syndicale des Constructeurs en Ciment armé, whose President, M. Edmond Coignet, is a son of the famous inventor, and by M. Hennebique, whose reputation as a designer of reinforced concrete is world-wide.
>
> The deputation consisted of: Sir Henry Tanner, I.S.O., F.R.I.B.A. (Principal Architect, H.M. Office of Works); Mr. William Dunn, F.R.I.B.A.; Mr. F. A. White (Chairman of the Associated Portland Cement Manufacturers (1900), Ltd.); Mr. A. Ross, M.Inst.C.E. (Chief Engineer Great Northern Railway); Mr. C. H. Colson, M.Inst.C.E. (Admiralty); Mr. W. G. Kirkaldy, A.M.Inst.C.E.; Mr. J. S. E. de Vesian, M.Inst.C.E.; Mr. F. E. Wentworth-Sheilds, M.Inst.C.E.; Mr. E. P. Wells, J. P.; Mr. H. K. Dyson; Mr. H. K. G. Bamber, A.Inst.C.E., F.C.S.; Capt. Gibson-Fleming, R.E.; Mr. G. C. Workman; Mr. P. W. Leslie; Mr. H. H. D. Anderson, and Mr. P. M. Fraser, A.M.Inst.C.E.
>
> It is understood that the deputation were well satisfied with the results of their inspection, which will form the subject of a special report.

THE WATERFORD BRIDGE.

It is with great pleasure that we hear that the almost interminable controversy regarding this bridge has now been definitely settled by the authorities in question specifying a reinforced concrete bridge, and the necessary order in Council, together with the requisite specifications, have been approved.

It will be remembered that this was a case where advocates of a more expensive steel structure used all their power and influence to avoid the cheaper and more serviceable material being used, and the victory for the advocates of reinforced concrete is certainly a most important one.

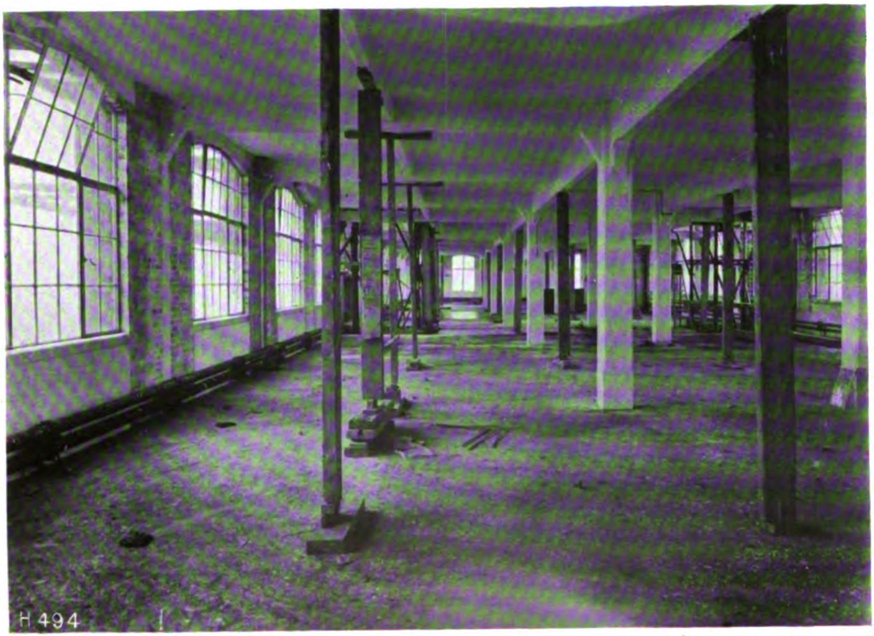


REINFORCED CONCRETE FACTORY · AT · HAYES.

We are glad to again be able to give particulars of a very important building being erected in reinforced concrete, as it is a striking example of the advantages that material affords for work of this character.—ED.

ONE of the most important undertakings in reinforced concrete construction erected in this country forms the subject of our article, and should prove of great interest to our readers owing to the magnitude of the work, which is plainly seen in the drawings and photographs in our illustrations, as well as being a noteworthy example of the practical use of reinforced concrete for factory construction.

The building is one of the Orchestrelle Company's new factories at Hayes, Middlesex, put up by Stuart's Granolithic Company, and two more blocks—*viz.*, the music roll factory and the stencilling building—are in course of construction by this firm, and we hope shortly to be able to give an account in our columns of these buildings, together with photographs and details of the work.

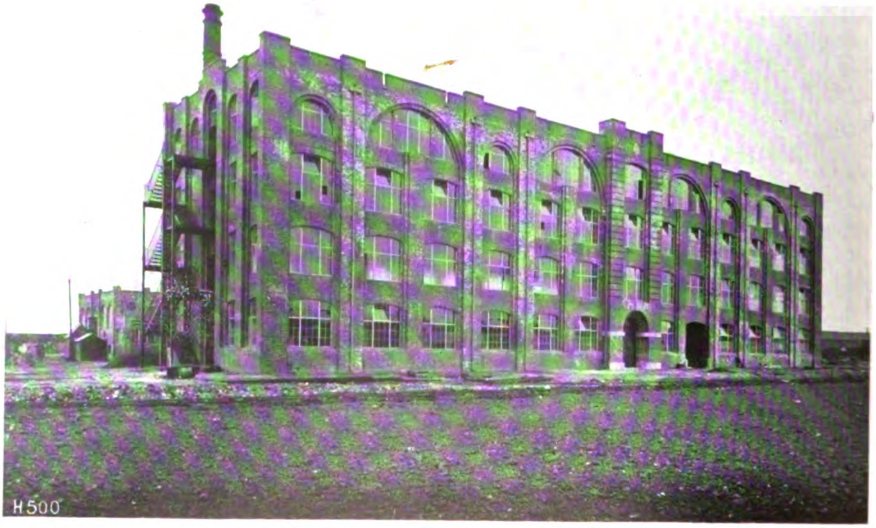


Second floor, Pianola building.
ORCHESTRELLE COMPANY'S FACTORY, HAYES.

The block of buildings here described consists of :—

(a) The Pianola factory, which contains four floors and a flat roof. It is 193 ft. long and 48 ft. wide. The floors are designed and executed to sustain a safe loading of 3 cwt. per foot of surface; the roof is designed for 1·50 cwt. The floors are covered with Stuart's Patent Granolithic laid at the same time

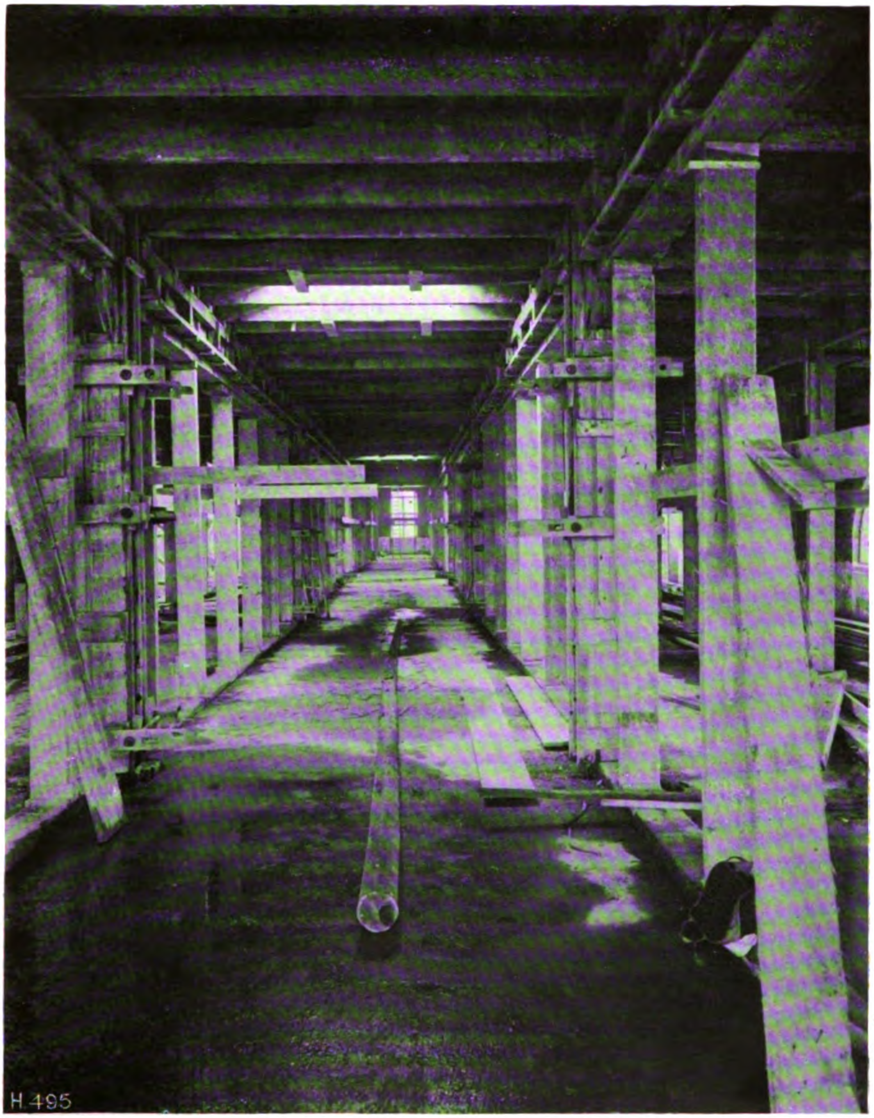
View of P'anola building, Power House, and Drying Room building.



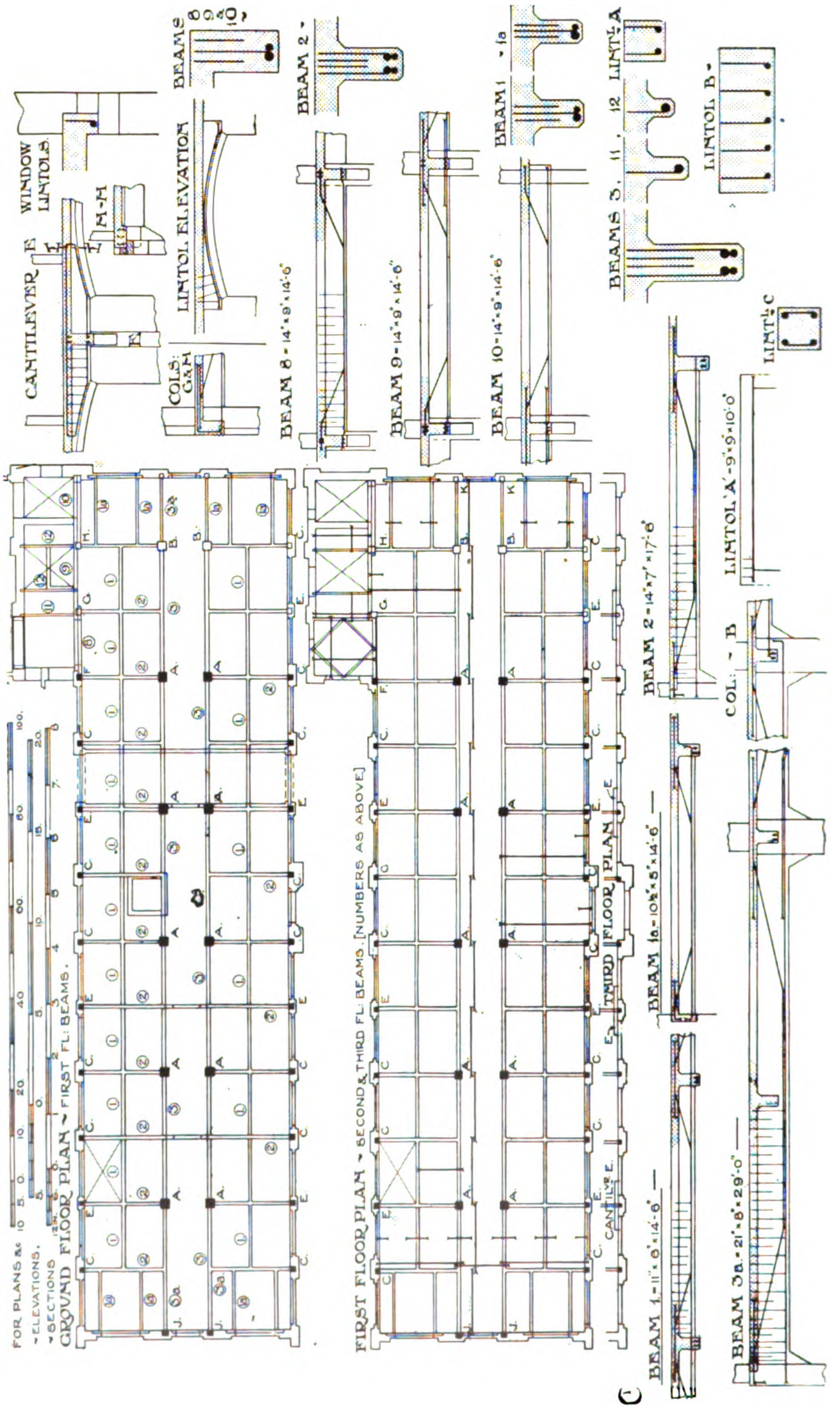
Pianola building.
ORCHESTRELLE COMPANY'S FACTORY, HAYES.

as the reinforced concrete work. The roofs are finished with asphalte as a weather-proof covering.

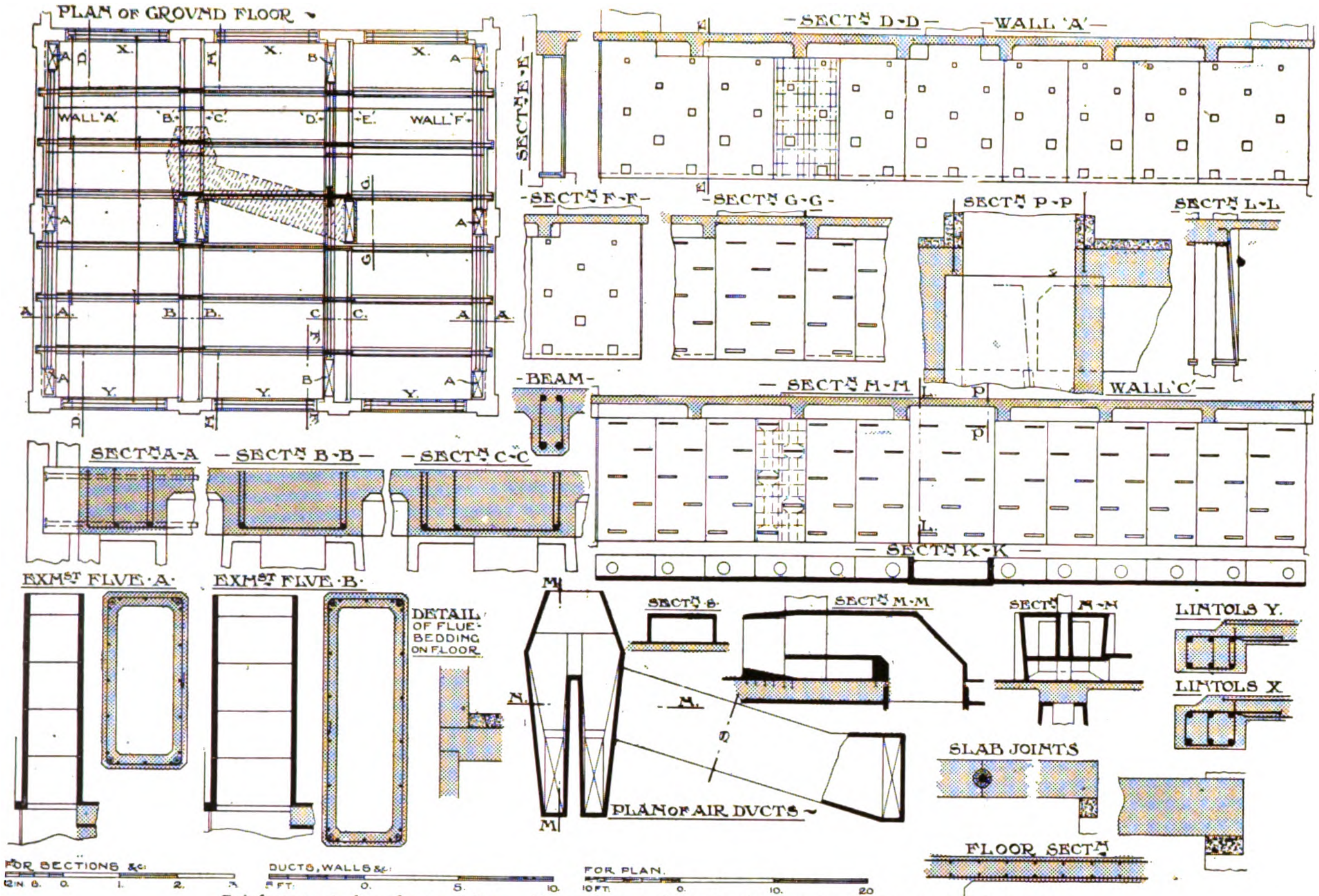
(b) The power house, consisting of two floors and flat roofs at different levels. This building is 80 ft. by 80 ft., particulars of which are shown in the drawing illustrated on page 311. The floors were also designed in this case to carry a safe load of 3 cwt. per foot of surface with 1·50 cwt. for the roof.



Pianola Building. Third Floor during construction.
ORCHESTRELLE COMPANY'S FACTORY, HAYES.

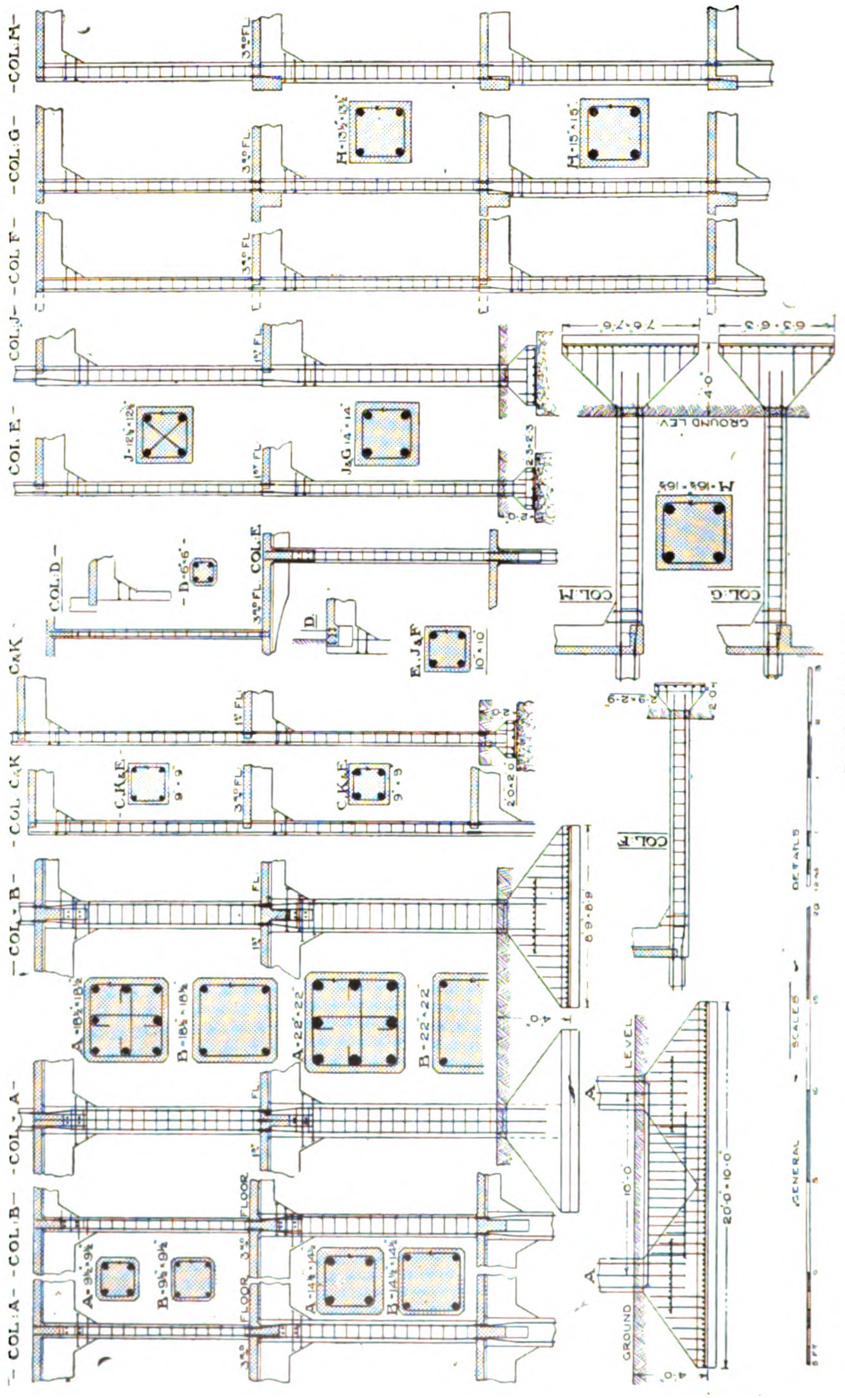


Framing Details of Floors and Beams.
ORCHESTRELLE COMPANY'S FACTORY, HAYES.

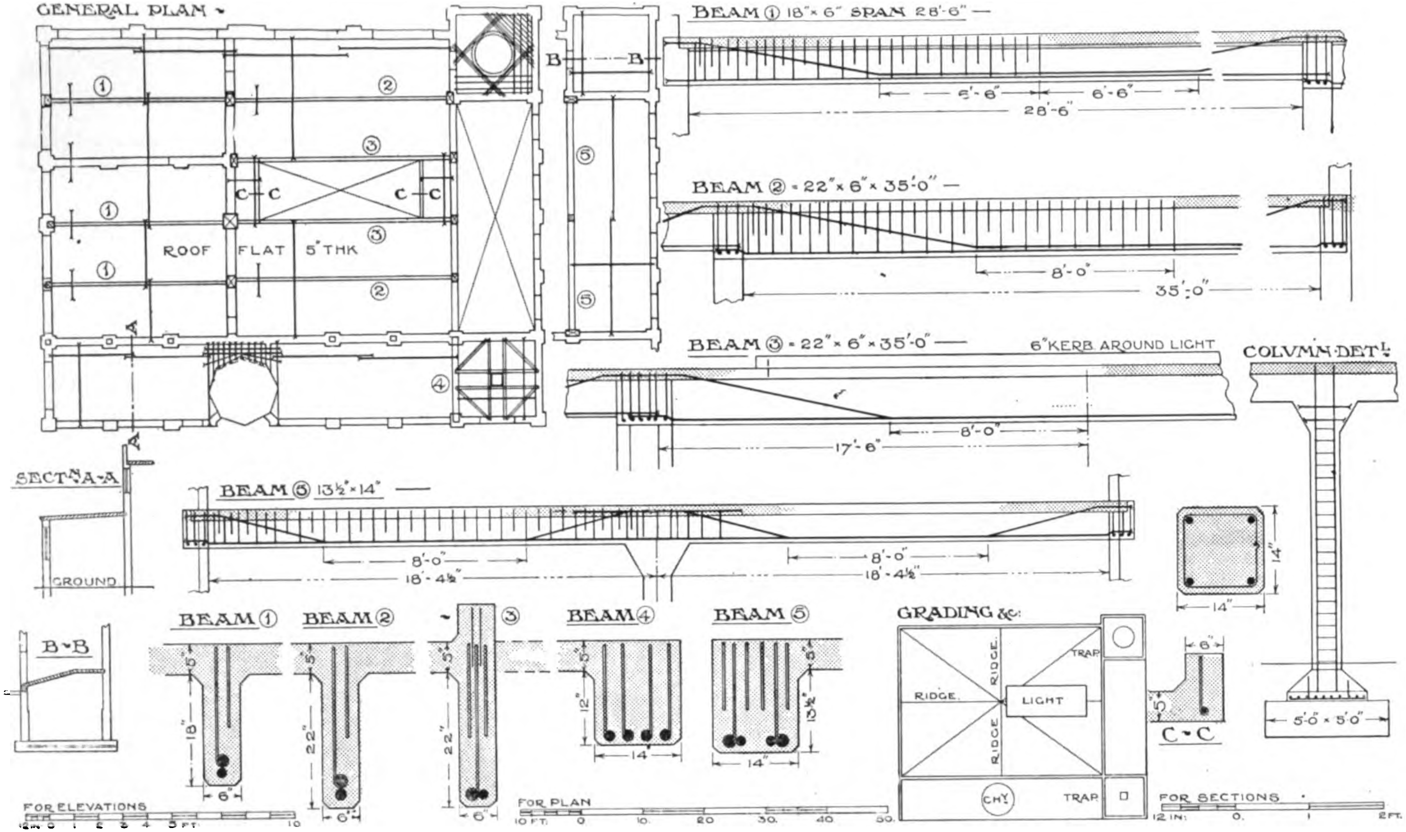


Reinforcement plan of ground floor. Also sections and details of slab walls for the wood drying process.

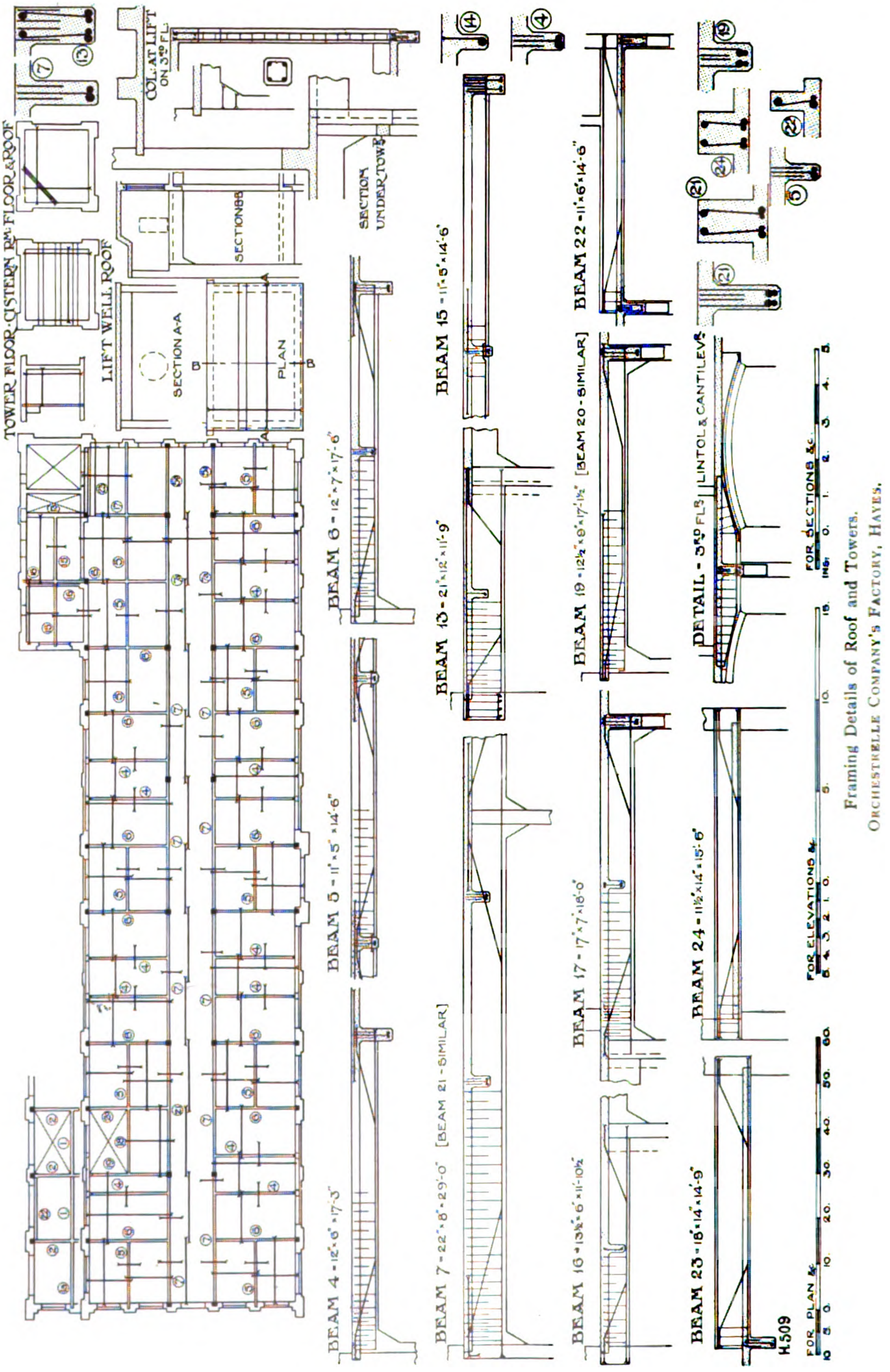
DRYING ROOM.



Details of Columns.
PIANOLA BUILDING.



Details of Power House, Roof, etc.
ORCHESTRELLE COMPANY'S FACTORY, HAYES.


TOWER FLOOR-CISTERN RM: FLOOR & ROOF
LIFT WELL ROOF
COL: AT LIFT ON 3RD FL.
SECTION UNDER TOWR
SECTION B-B
SECTION A-A
PLAN
A
B
BEAM 6 - 12"×7"×17'-6"
BEAM 5 - 11"×5"×14'-6"
BEAM 4 - 12"×6"×17'-3"
BEAM 15 - 11"×5"×14'-6"
BEAM 13 - 21"×12"×11'-9"
BEAM 7 - 22"×8"×29'-0" [BEAM 21 - SIMILAR]
BEAM 22 - 11"×6"×14'-6"
BEAM 19 - 12½"×8"×17'-1½" [BEAM 20 - SIMILAR]
BEAM 17 - 17"×7"×18'-0"
BEAM 16 - 13½"×6"×11'-10½"
DETAIL - 3RD FLR LINTOL & CANTILEVR
BEAM 24 - 11½"×14"×15'-6"
BEAM 23 - 18"×14"×14'-9"
FOR SECTIONS &c. INS. 0 1 2 3 4 5
FOR ELEVATIONS &c. 6 5 4 3 2 1 0 5 10 15
FOR PLAN &c. 10 5 0 10 20 30 40 50 60
H.509

Framing Details of Roof and Towers.

Orchestrelle Company's Factory, Hayes.

Roof of Pianola Building.

First Floor, Pianola Buildings.
ORCHESTRELLE COMPANY'S FACTORY, HAYES.

(c) The drying-room building, measuring 49 ft. by 41 ft., and having two floors. In this building Messrs. Stuart's Granolithic Co. have installed a most ingenious system of reinforced concrete slab walls, made up of graded thicknesses of stone and joggled and jointed, and having bevelled slits for the passage of the air which is required for the drying of the timber used in the Orchestrelle Company's productions. The system of drying, we understand, is a patent one, and we cannot therefore give particulars or details of the process employed.

(d) The coverings of ducts throughout the several buildings and in yards, approximating to some 800 ft. of varying widths. These are made sufficiently strong to take the loading and traffic that will circulate upon them.

Almost all the floor space on the solid ground is covered with Stuart's Patent Granolithic Paving.

The framing of the beams and columns is shown by the accompanying plans to reduced scale. The prevailing idea was to have the buildings supported by reinforced concrete columns resting on similar foundations and then to fill in between the panels with brickwork.

The whole offers a most pleasing result of the combination of brickwork and reinforced concrete, and to all those interested in adopting these materials it is well worth a visit to Hayes to inspect this factory, as the building is extremely artistic as well as most practical.

The work was originally designed for steel girders, joists, and concrete floors, but the architect ultimately decided on having a reinforced concrete structure, which has appreciably reduced the cost.

As above mentioned, Messrs. Stuart's Granolithic Co., of Fenchurch Street, were responsible for the reinforced concrete work, Mr. E. P. Wells, their consulting engineer, preparing the working drawings. Messrs. Fryer and Co., of Paddington, were the general contractors, and Mr. Walter Cave, of Old Burlington Street, W., the architect, to whose design and under whose instruction the whole of the work has been carried out.

QUANTITIES and ESTIMATES for REINFORCED CONCRETE.

By H. KEMPTON DYSON, C.E.,
Technical Secretary, Concrete Institute.

In view of the great necessity for the standardisation of methods for reinforced concrete work, we think an article on the preparation of Estimates should prove of interest.—ED.

In the February issue of this journal an article was published relating to standard methods for the preparation of reinforced concrete drawings, in which the author referred to the advantages to be obtained from the adoption of standard methods of executing drawings submitted with tenders for reinforced concrete work. Detailed consideration of the subject was there given, with suggestions of ways in which labour could be saved by the general adoption of such standards. It was stated at the conclusion of the article that standard methods in the drawing office had a relation to standard methods in the preparation of estimates, and also in the execution of work. We may now consider this latter aspect of standardisation.

To classify details of the work for consultation by the draughtsmen, the estimating staff, and, at a later stage, the executive staff, is but an adjunct to the work of design. It seems a general custom to prepare schedules of the sizes of beams and columns in tabular form, giving particulars of the sizes of the reinforcements in each part of any design. In the United States, in connection with steel-frame buildings, the scheduling of sizes and quantities has arrived at some measure of standardisation, and the author suggests the adoption of tabulated statements conforming generally to the American standard scheduling.

COLUMN SCHEDULE.

In tall structures it is customary to reduce the loads on columns or pillars from those adopted in calculating the floor slabs and beams. This is based on the idea that it is quite impossible for the entire floor in every storey of a building to be loaded to the maximum at the same time. The Joint Committee on Reinforced Concrete appointed by the Royal Institute of British Architects has suggested certain rules as regards the amount of reduction of the floor loads on columns. These, in short, were simply that the roof load was to be taken at the full; that the live load on the storey below the roof was to be reduced by 10 per cent.; the live load on the storey below that another 10 per cent. (*i.e.*, 20 per cent.); the storey below that another 10 per cent. (*i.e.*, 30 per cent.), and so on until the reduction of the live load on any particular floor amounted to 50 per cent.

In tall structures with many floors the column loads are made up of several separate items, each varying in amount, and, in order to minimise the risk of error and omission, it is very desirable that the loads should be detailed in some tabular form of statement, which would act almost as an automatic check. In such a schedule the loads transferred through the columns down to the foundations should be set out in detail, so as to show the gradual accumulation of the load. In skeleton or frame construction the column loads include floor and live loads, wind loads, spandrel and pier loads, the weight of the columns themselves and their fire-resisting or decorative covering, and, in some cases, special loads, such as tanks, strong rooms, safes, lifts, etc. In tabulating the floor-slabs also it is not only important, with a view to a reduction of the loads upon the columns, to separate the total load into dead and live loads, but as affecting the design of the foundations, for as a rule these are designed to carry only a small proportion of the live load. In very tall structures the wind loads also need to be considered, both for designing the columns and for dimensioning the foundations, though in buildings not exceeding 100 ft. in height the wind loads are generally disregarded. It is also important to tabulate separately the eccentric loads on columns, because the matter of eccentricity in the loading is often disregarded, whereas merely a small amount has a considerable effect in reducing the strength of a column. In the following column sheet, which is suggested as suitable for ordinary purposes, it will be noticed that the total load of each storey is the sum of all the loads above.

FORM OF COLUMN SCHEDULE.

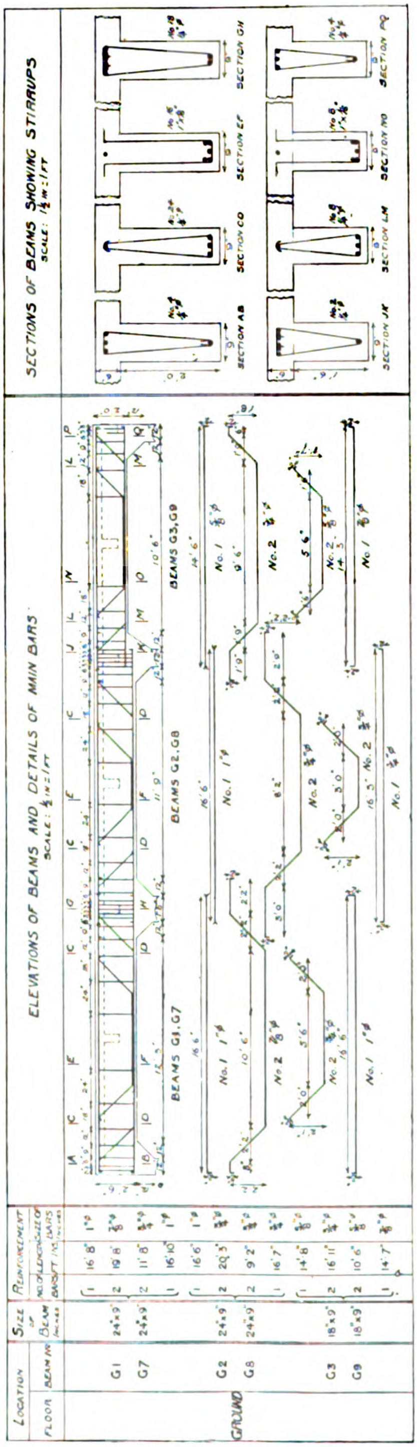
Storey.	—	Column No. 1.		Column No. 2.	
		Concentric Load on Column.	Eccentric Load on Column.	Concentric Load on Column.	Eccentric Load on Column.
7th Storey	Roof and ceiling, dead load				
	Roof and ceiling, live load				
	Beams				
	Spandrels, cornices, etc.				
	Brick or stone piers				
	Walls				
	Lifts				
	Tanks				
	Column and casing				
	Wind				
	Total				
	Sectional area required	in.^{2}		in.^{2}	
6th Storey	From column above				
	Floor and ceiling, dead load				
	Floor and ceiling, live load				
	Beams				
	Spandrels, cornices, etc.				
	Brick or stone piers				
	Walls				
	Strong rooms, etc.				
	Column and casing				
	Wind				
	Total				
	Sectional area required	in.^{2}		in.^{2}	
Basement	From column above				
	Floor and ceiling, dead load				
	Floor and ceiling, live load				
	Beams				
	Spandrels, cornices, etc.				
	Brick or stone piers				
	Walls				
	Footpath				
	Column and casing				
	Wind				
	Total				
	Sectional area required	in.^{2}		in.^{2}	
Foundations	Deduct ($\frac{1}{2}$) live load				
	Total foundation load				
	Area of foundation required	ft.^{2}		ft.^{2}	

SCHEDULES FOR MATERIALS.

We now come to the question of schedules for materials. Here, again, we obtain help from the same standardised methods adopted in the United States in connection with structural steelwork. On the following page is the type of table suggested. It will be seen that in the diagrams showing how the rods are to be bent and otherwise dealt with angle measurements are not stated, but only the general lengths and distances to which the reinforcements are to be worked. This is much more accurate and more convenient than attempting to work to angle measurements, especially in the shops, for the great point is that the steel should secure a close connection with the other reinforcements which may not be detailed on the particular schedule given to the workman, and if he had to work to an angle measurement the merest fraction would throw the work out. No templates or setting out upon the floor to full size are required by this method. By scheduling the reinforcements in this way it will be found generally that the steel can be fabricated in the shops more economically than upon the job, though this is not a hard and fast rule, and it is often more advantageous to execute the cranking and bending of the reinforcements in close proximity to the work. Such a schedule, with the omission of some of the particulars relative to bends and cranks, and the diagrams relating to same, will also serve in connection with preliminary drawings supplied to an architect or engineer.

QUANTITIES.

From the schedules provided with a preliminary drawing and the general drawing, showing the construction, the quantities are taken out, and the detailed working or shop schedules can be prepared more or less as an elaboration of the quantities; therefore, in taking out these latter, it will be found economical of time and generally advantageous if they are drawn up upon some system whereby assistance is given in the preparation of the detailed schedules of materials at a later stage when the work has been secured. In the method of taking out quantities for reinforced concrete, naturally one would expect to conform to general practice in respect to quantity taking, but there is a difference in the fact that in this system of construction the reinforcements are so numerous and contain so many labours that the ordinary method of quantity taking is very tedious and can neither be checked nor got out so easily as where a method of tabulation is adopted. Some constructors have adopted such tabulated statements for quantity taking, and the one appended hereto, in the author's opinion, meets all requirements. It is, perhaps, rather elaborate, but it is of the greatest assistance in the estimating to have full details provided. The quantities supplied by many specialists at the present date are not nearly sufficiently detailed to enable close estimating to be effected. It is quite inadequate to price up steelwork at so much per ton, including all labours, because the latter vary so very much. Attempts have been made to average such work, and sometimes a portion is taken out in detail to give a basis for pricing per ton, but unless it is taken over a large quantity, and the work is exactly similar in character, the system of estimating by averages may err very greatly—on the one hand the prices may be far too little, on the other hand



they may be too high. In the first case the profits made will be much reduced, and, in fact, in some cases a loss sustained; while in the latter event the estimate may be too high and the work be lost.

It is, perhaps, too early yet to say that there is any recognised system of quantity taking for reinforced concrete. The quantity surveyors, as a profession, will probably say that there is nothing new in taking out quantities for such work, that the ordinary methods that have been adopted for steelwork and fire-resisting floors may be employed for reinforced concrete. Specialists in the latter material, however, generally think otherwise.

In taking out quantities by any method some system must be observed, and the only items in which there seems to be any established custom are (1) that the floor-slab should be taken over the whole area of the floor and be taken as the same thickness throughout as it is between beams, and (2) that the depth of the beams, although, strictly speaking, extending from the soffit to the top surface of the concrete of the floor-slab, should be taken as only from the soffit of the beams to the underside of the floor-slab. The correctness of this policy may be doubted, because where top reinforcements are provided in beams these are placed in the portion of concrete usually counted as part of the floor-slab, and the labour of placing same cannot be counted as a percentage on the total area of the floor-slab. Also, if we price the concrete in a beam at so much per foot cube, say, then we must remember that we are omitting, in taking the size of the beam, a certain amount of concrete which has already been taken in the floor-slab by the customary method. However, perhaps this is not so very serious, though theoretically objectionable. The labour of putting these steel reinforcements in place is not so very great, and where there is considerable amount of top reinforcement the estimator can make a sufficiently accurate allowance. As, in estimating, the price of the concrete should be varied according to the thickness of the floor-slab, it is important to have the concrete in the floor-slabs stated in square yards of a certain thickness, and not in yards cube, as is often done.

The centering for the floor-slabs is usually taken over the whole area of the floor, though here, again, it would be more correct if the extent of the beams were deducted therefrom; however, the extra area is not of much consequence, as, if this be recognised as the custom, we can assume that this extra allowance of material covers the cost of fitting to beam boxes.

As regards beams and columns, one often finds the quantity of concrete stated at per yard cube, but it is more convenient to state it in feet cube. The size of each beam and column should be detailed and the feet run of each particular size may, with advantage, be stated, as the price must be proportionately increased for beams and columns of small size and small quantity. Any labours to beams and columns, such as chamfered edges, etc., should be detailed separately at per foot run, both in concrete items and in boxing items. In taking the girths of the boxings no allowance is usually made for the thickness of the boards, and the quantities should be stated in feet super. Small work under 12-in. girth should be stated separately at per foot run.

As regards the quantities of steel, it is a question as to whether this should be stated at per ton, per cwt., or per lb. The tendency at the moment seems to be in the direction of stating the quantity in tons, but as the weight is generally taken in pounds some contractors prefer to price the work at per lb., thinking that thereby labour is saved, but as the lb. is such a small unit the price cannot be so closely varied as is thought desirable by some estimators. Sometimes, for instance, work is priced at 1⅛d. per lb., on other occasions, when this price is not considered sufficient, 1¼d. is adopted, and then again, if this is not sufficient, the next price that will be put down is 1⅜d., or again, 1½d. These prices, it will be noted, amount respectively to £10 10s., £11 13s. 4d., £12 16s 8d., and £14 per ton. It will be seen that the difference between each price is considerable. On the other hand, the objection that is raised to using a ton as a unit is that not only must the quantities be converted, but they often amount to less than a ton, so that when the amount is stated in tons the total tonnage may be very small. Indeed, for any particular work, the quantity of steel rods may often not even amount to a ton. The conversion from pounds into some other unit the author thinks is advisable, but the objection to using the ton can be counteracted by employing the cwt. as a unit. This is convenient, too, because the price per ton at which we buy the steel, and from which the estimator is accustomed to build up his price mentally, can be read immediately in cwts. by taking the pounds as shillings.

It is important to detail the size of these reinforcements as well as to give weights, because manufacturers charge different prices for rods of different dimensions, small rods being often more expensive than the larger sizes.

QUANTITIES.

FLOOR AND WALL

LOCATION.		CONCRETE.											CENTERING.			
Floor	Slab No.	No. of Times	Length	Width	Thickness	3-in.	3½-in.	4-in.	4½-in.	5-in.	5½-in.	6-in.	No. of Times	Length	Width	Superfi'l Area
			ft.	ft.	in.	ft. sup.	ft. sup.	ft. sup.	ft. sup.	ft. sup.	ft. sup.	ft. sup.		ft.	ft.	ft.
Ground	A	6	8	8	4			384					6	8	8	384
Do.	B	4	10	10	5					100			4	10	10	100
First	C	10	6	18	3	1080							10	6	18	1080
						9)1080		9)384		9)100						9)1564
Carried to Bill.						=120 yds.sup.		=42·66 yds.sup.		=11·11 yds.sup.						=173·77 yds. sup.

BEAM

LOCATION,		CONCRETE.				CENTERING.				STEEL									
Floor	Beam No.	No. of Times	Length	Depth & Breadth	Cubical Contents	No. of Times	Length	Girth	Superfi'l Area	No. of Bars in Beams	Length	Size of Bars	⅜-in.	½-in.	⅝-in.	¾-in.	⅞-in.	1-in.	1⅛-in.
			ft.	in.	ft.		ft.	in.	ft.		ft. in.	in.	ft.	ft.	ft.	ft. in.	ft. in.	ft. in.	ft.
Ground	G1 G7	2	16	24×9	48	2	16	57	152	2	16 8	1 φ						33 4	
										4	19 8	⅞φ					78 8		
										4	11 8	¾φ				46 8			
										2	16 10	1 φ						33 8	
					27)48				9)152							46 8 × 1·502 lb.	78 8 × 2·044 lb.	67 0 × 2·67 lb.	
Carried to Bill.					=1·78 yds. cu.				=16·9 yds.sup.							=·627 cwt.	=1·44 cwt.	=1·6 cwt.	

COLUMN

LOCATION.		CONCRETE.				CENTERING.				LONGITUDINAL STEEL RODS.										
Floor	Column No.	No. of Times	Height	Side × Side	Cubical Contents	No. of Times	Height	Girth	Superfic'l Area	No. of Bars in Columns	Length	Size of Bars	½-in.	⅝-in.	¾-in.	⅞-in.	1-in.	1⅛-in.	1¼-in.	1⅜-in.
			ft.	in.	ft. in.		ft. in.	in.	ft.		ft.	in.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
Ground	G1-10	10	11	14×14	150 0	10	10 6	56	490	40	12	1¼φ							480	
First	F1-10	10	10	10×10	69 5	10	9 8	40	322	40	9	½φ	360							
					27)219·5				9)812·0				360 0 × ·667 lb.						480 0 × 4·173lb.	
					=8·13 yds. cu.				=90·2 yds. sup.				=2·14cwt.						=17·9cwt.	

NAME OF JOB.

SLAB SCHEDULE.

STEEL RODS.								NUMBER OF BENDS & CRANKS IN RODS.		NUMBER OF HOOKED ENDS TO RODS.		WIRE TYINGS
Spacing of Rods	No. of Rods	Length	Size of Rods	¼-in.	⅜-in.	½-in.	⅝-in.	¼-in. ⅜-in.	½-in. ⅝-in.	¼-in. ⅜-in.	½-in. ⅝-in.	Number
in.		ft. in.	in.	ft.	ft.	ft.	ft.					
6	96	8 0	⅜		768					192		768
12	48	12 0	⅜		576			192		96		
6	80	10 0	⅝				800				160	360
5	96	14 0	½			1344			384		192	
3	72	8 6	¼	6120				2880				140
18	40	18 0	⅜		720							
				6120 × ·167 lbs.	2064 × ·375 lbs.	1344 × ·667 lbs.	800 × 1·043 lbs.					
				=9·1 cwt.	=6·92 cwt.	=8·02 cwt.	=7·45 cwt.	3072	384	288	352	1268

SCHEDULE.

RODS.					NUMBER OF BENDS & CRANKS IN RODS.					NUMBER OF HOOKED ENDS TO RODS.			NUMBER OF SPLIT ENDS TO RODS.		STIRRUPS.					
1¼-in.	1⅜-in.	1½-in.	1¾-in.	2-in.	⅜-in. to ⅝-in.	¾-in. to 1-in.	1⅛-in. to 1¼-in.	1⅜-in. to 1½-in.	1¾-in. to 2-in.	⅜-in. to ⅝-in.	¾-in. to 1 in.	1⅛-in. to 2-in.	⅜-in. to ¾-in.	1-in. to 2-in.	Kind	No. of Stirrups	Length	Size	¼-in.	1-in. × 1/16-in.
ft.	ft.	ft.	ft.	ft.													in.	in.	ft. in.	ft. in.
						—					2			2	U	4	63	¼	21 0	—
						16					8			—	Link	10	63	¼	52 6	—
						8					8			—	Link	8	62	1 × 1/16		41 4
						—					4			—	Link	6	65	¼	32 6	—
																			106 0 × ·167 lb.	41 4 × ·212 lb.
						24					22								= ·158 cwt.	= ·078 cwt.

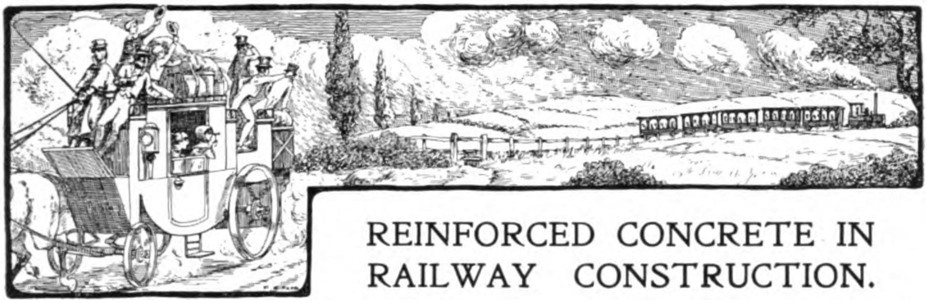
SCHEDULE.

				NUMBER OF BENDS AND CRANKS IN RODS.					BINDERS.											WIRE TYINGS.
1½-in.	1⅝-in.	1¾-in.	2-in.	⅜-in. to ⅝-in.	¾-in. to 1-in.	1⅛-in. to 1¼-in.	1⅜-in. to 1½-in.	1⅝-in. to 2-in.	Kind	Pitch or Spacing	Number	Length	Size	1/16-in.	⅛-in.	3/16-in.	¼-in.	5/16-in.	⅜-in.	Number
ft.	ft.	ft.	ft.							in.	in.	in.	in.	ft. in.	ft.	ft.	ft. in.	ft.	ft.	
						40			φ Links	6	240	44	1/16 φ	880 0						
				—					φ Spiral	3	—	800	¼				666 8			360
						—								880 0 × ·01045 lb.			666 8 × ·167 lb.			
						40								= ·082 cwt.			= ·0994 cwt.			360

In the schedule it is fairly easy to record the labours in sufficient detail without much trouble, and therefore the objection that is raised to giving these labours—namely, that the time for getting out the quantities in the preliminary stages of tendering is insufficient—is met, and the dissatisfaction often occasioned by the estimator having to approximate the cost per cwt. from an inspection of the drawings can be avoided. It is suggested that sufficient detail is given by recording each reinforcement connected with each beam and column, stating the number, sizes and sections of the main bars; the number of all cranks, fishtailed or bent ends in the bars of each section; the number and size and character of each reinforcement, each stirrup or tie, the number and size of any top reinforcing rods, and, finally, detailing all special labours separately. From the form of schedule here provided, the manner in which this can be done without incurring much trouble and without taking up too much time is clearly shown. The total quantity of each particular item is obtained by adding up each column. Such a schedule is very easy of reference afterwards if it be desired to check any particular part of the work.

In detailing the reinforcements in floor-slabs it is desirable to state the number of the rods and whether these are laid direct or in meshwork arrangement, also the number of bent ends should be recorded, and the number and size of the cranked rods.

As it is advantageous to be able to estimate the cost of wiring the inter-sections of reinforcements arranged in a meshwork, for a great deal of money is often spent upon such apparently small items, therefore it is desirable that the estimator should be provided with some data in this respect. The weight of wire is not, as a rule, furnished, and, of course, it is not exactly a simple matter to ascertain this with any great degree of accuracy, but the size of the wire can at least be specified, together with the number of inter-sections required to be wired per unit of area or length—*i.e.*, per square yard in floor-slabs, or per foot run in beams and columns. The approximate amount of wiring necessary can be ascertained by taking out a small portion, adding up the number of wired inter-sections, and then multiplying over the whole area or total length.



REINFORCED CONCRETE IN RAILWAY CONSTRUCTION.

As much greater use of reinforcea concrete for railway work has been made in America than in this country, the principal examples in this article are taken from the United States, and we are indebted to the Atlas Cement Co. of New York for allowing us to reproduce some of the illustrations which appeared in their recent booklet published on this subject.—ED.

STATIONS AND PLATFORMS.

A GREAT number of the American railways have utilised concrete in the construction of stations of all kinds, and where not adopted for the entire structure it is frequently used for a portion of the work, such as platforms, foundations, staircases, smoke ducts, and platform columns. It is easily adapted, has the great advantages of fire-resisting qualities, and is permanent, while the illustration of Marathon station, *Fig.* 10, shows that it is capable of architectural treatment of no mean order. This structure is a combination passenger station and freight house, and, with the exception of the roof, the building is of concrete construction throughout. The foundations and main walls are of plain concrete, the only reinforcement employed consisting of three ¼-in. square

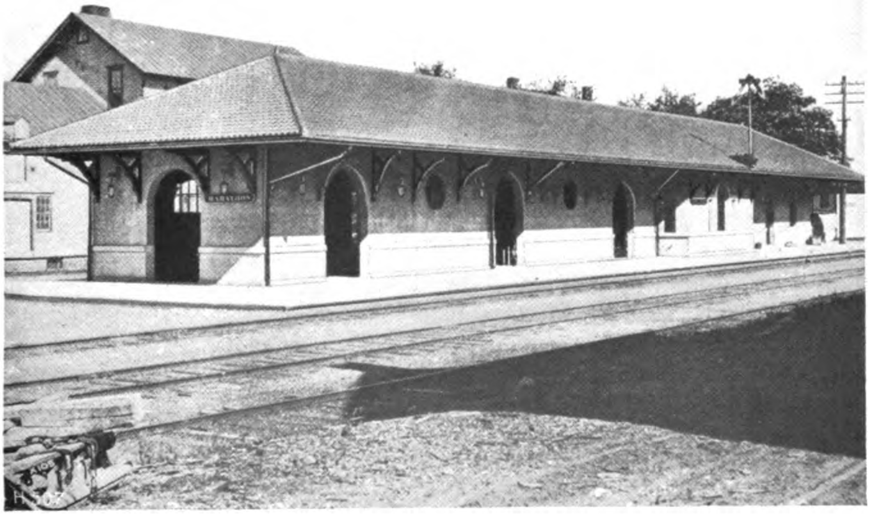


FIG. 10. MARATHON STATION.

rods near the soffits of all lintels over square openings, while the floors and platforms are of plain concrete laid directly on a cinder base and finished with granolithic 1½ in. thick. The lower parts of the walls are tool finished, while the upper parts are finished by floating the concrete with water and rubbing with wire brushes immediately after the forms are removed. The whole of the concrete was mixed in the proportions of 1 part Portland cement to 2 parts sand and 4 parts of broken stone. Platforms have been constructed in plain concrete for many years past, but the adoption of high platforms on rapid transit and suburban lines in more recent times has led to the use of reinforced concrete as being more economical.

A typical ground platform constructed in plain concrete, mixed in the proportions of 1 part Portland cement, 3 parts sand and 6 parts broken stone, is that illustrated in *Fig.* 11, which is a photograph of Cohoes station and platform, N.Y.C. and H.R. Rly. These platforms are usually constructed 200 ft. long and 12 ft. wide and are divided into blocks of not more than 40 sq. ft. area. The surface is usually finished with granolithic, mixed in the proportions of 1 part Portland cement to 1½ parts of sand. Many of the new train sheds on the American railways are quite a departure from the hitherto considered standard type of structure for this purpose. Instead of comprising a series of high arches, which in the common type of train shed are continually enveloped in a haze of smoke and gases from the locomotives, they consist essentially of a system of low-arched, short-span longitudinal sections, just high enough to clear the largest locomotive in use on the

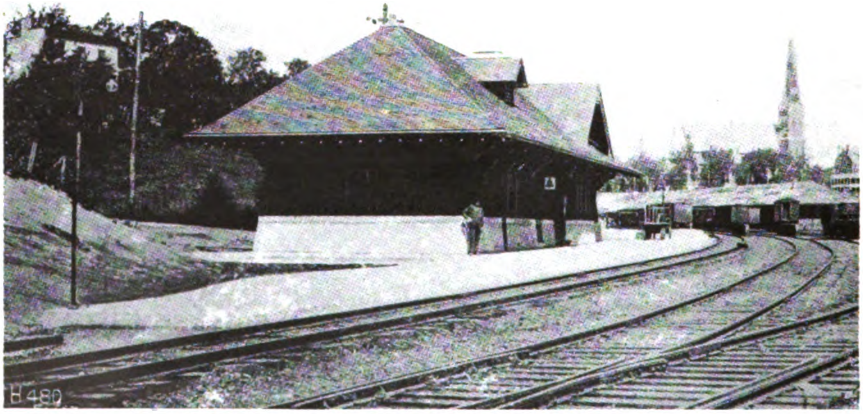


FIG. 11. COHOES STATION AND PLATFORM.

line, with smoke ducts of reinforced concrete, through which the locomotive gases are discharged directly into the open air. These smoke ducts are built high enough to prevent driving rain or snow from reaching the platforms; while in addition to these ducts the roofs, platforms and any footings for fences are of concrete construction.

COAL AND SAND STATIONS AND ASH-HANDLING PLANTS.

Coal, when stored in great quantities, is subject to spontaneous combustion, which not only results in the loss of the coal itself, but also causes the destruction of the bin when the latter is constructed of either wood or steel, and this condition had led to the frequent use of structures composed entirely of reinforced concrete on account of the excellent fire-resisting qualities possessed by this material, while the results obtained have been such as to give entire satisfaction.

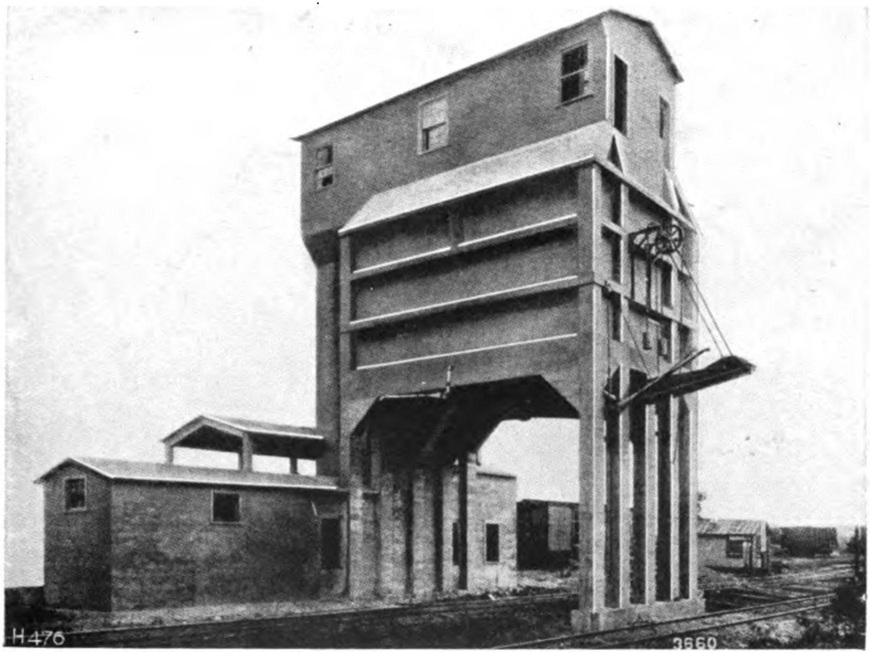


Fig. 12. Coal and Sand Station, N. & W. Railway.

A very good example of a combination coaling and sand station is that of the Concord coal and sand station, illustrated in *Fig.* 12. Generally speaking, the station consists of an elevated coal pocket having a capacity of 260 tons of coal, and a wet sand storage house on the ground with an elevated dry sand bin. The coal is brought to the pocket on a side track and dumped through a 10-ft. by 12-ft. track hopper into a reciprocating feeder, which delivers it into a steel bucket elevator discharging into a conveyor trough above for distribution into the pocket. It is fed to the engine tenders through hinged gates and over counter-weighted coaling shutes, two directly under the pocket and two over the track in front of the pocket. The wet sand passes into a dryer, emptying into a sand pit underneath, where it is scooped up and carried by a sand elevator, which dumps it from above into the dry sand bin. From this bin it is fed to the engines through two telescopic sand spouts. In designing the structural features of the station the unit compression in the concrete was taken as 500 lb. per sq. in. and the tension in the steel as 16,000 lb. per sq. in. The side walls were designed on the basis of the computed lateral pressure exerted by the bituminous coal weighing 47 lb. per cu. ft. This gave a maximum lateral pressure of 248 lb. at the bottom of the pocket and a vertical pressure on the bottom slab of nearly 1,000 lb. per sq. ft. The concrete was mixed in the proportion of 1 part of Portland cement to 2 parts sand and 4 parts broken stone, while the reinforcement consisted of ordinary round bars, from ¼ in. to 1 in. diameter, spaced at distances varying from 5 in. to 24 in. centres. In the case of ash-handling plants a great difficulty has had to be contended with to obtain a suitable material which would successfully withstand the destructive effect of ashes quenched with water. This has led to the use of reinforced concrete, and great satisfaction has been given by such a material, as the corrosion, which became such a serious defect in the case of steel, has been entirely avoided.

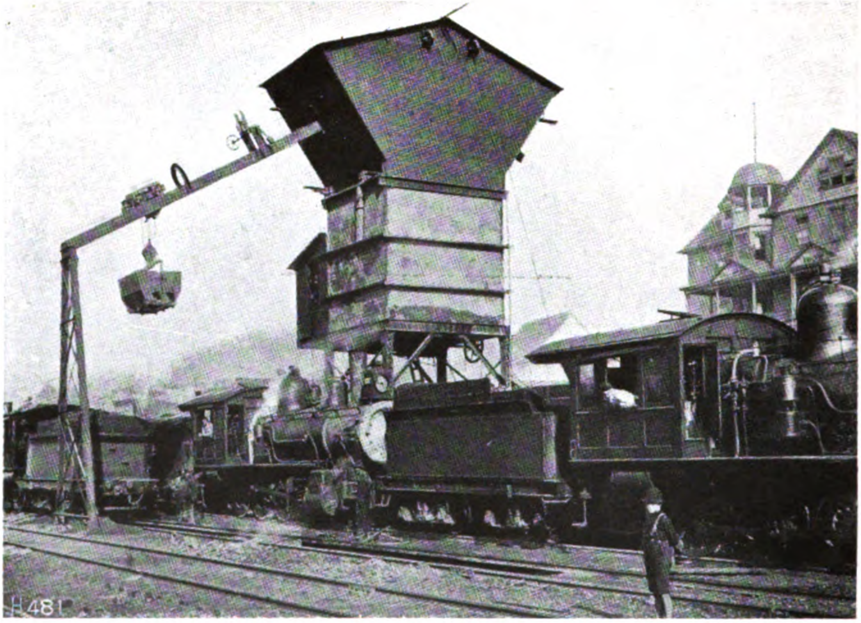


FIG. 13. ASH-HANDLING PLANT AT BLUEFIELD.

At the present time most of the plants being built throughout America consist of a steel framework, which supports bins constructed of reinforced concrete, and a good example is that illustrated in *Fig.* 13, which is a photograph of such a plant erected for the Norfolk and Western Railway at Bluefield. The ash bin has a storage capacity of 30 tons. Ashes are dumped from the engine into the 1-ton tubes which rest on trucks in the dump pit below, with their tops flush with the rails, and are raised, dumped into the bin and returned automatically by an electric hoist. In the photograph one of the skips is seen in action. The ashes are emptied from the bin through a discharge gate into cars on a track directly beneath. The height of the bin is about 13 ft. and the sides are formed of concrete which is only 3¼ in. for the upper 10 ft., spreading out to 6 in. thick at the bottom, while the reinforcement employed is expanded metal and the steel framework supporting the bin is built up of rolled steel joists and channels of various sizes.

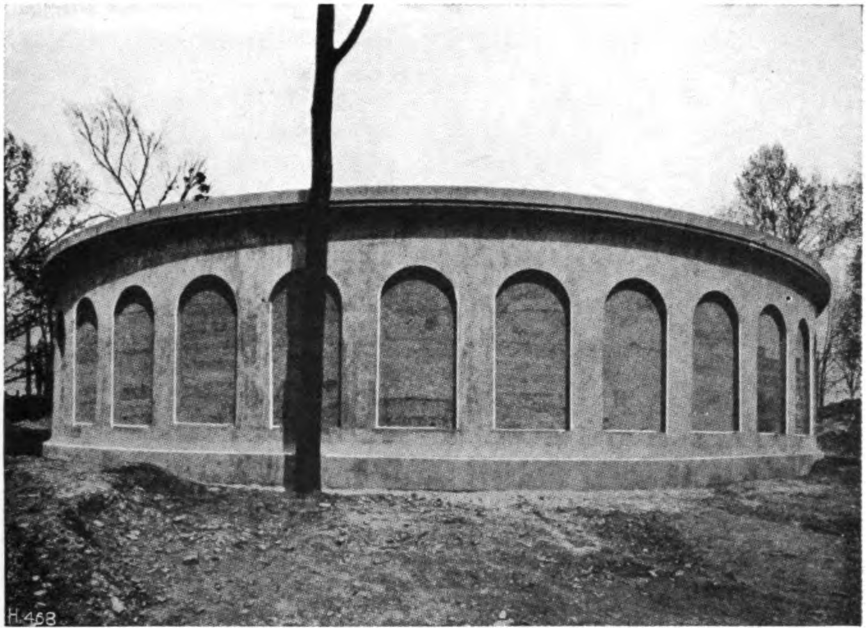


Fig. 14. Reinforced Concrete Roundhouse.

ROUNDHOUSES AND TURNTABLE PITS.

Concrete has been extensively used for this work and a saving has been effected in many cases in addition to an improvement in the type of structure obtained. In good work the foundations and pits are invariably of concrete, and when a good bearing cannot be obtained at a level of a few feet below the floor line a great saving can be effected by the use of reinforcement. For the construction of the roof there is no material to equal reinforced concrete and the use of steel alone for this work is to be condemned, on account of its inferiority as regards durability and fire-resisting qualities, and where the roof is constructed of the former material the most satisfactory method is to employ the same in the supporting columns. The columns on the inner circle, to which the doors are attached, can with advantage be of steel or cast iron in preference to concrete. In the case of a structure roofed with reinforced concrete the outer walls may be of brick, plain concrete, reinforced concrete, or plaster.

Concrete will give good results under nearly all conditions, while plaster walls may be employed when it is required to reduce the initial outlay to a minimum. These walls are constructed of expanded metal covered with Portland cement mixed with sufficient lime to allow it to be worked with a trowel. The former is stiffened with rods and channel irons, which are used to support the window frames. A wall of this character can be built more quickly than a concrete wall, is efficient and should be durable. If damaged by a locomotive, or otherwise, it is easily repaired and alterations can be readily made. When used with concrete columns it should not crack and its first cost is only about one-half that of a brick wall.

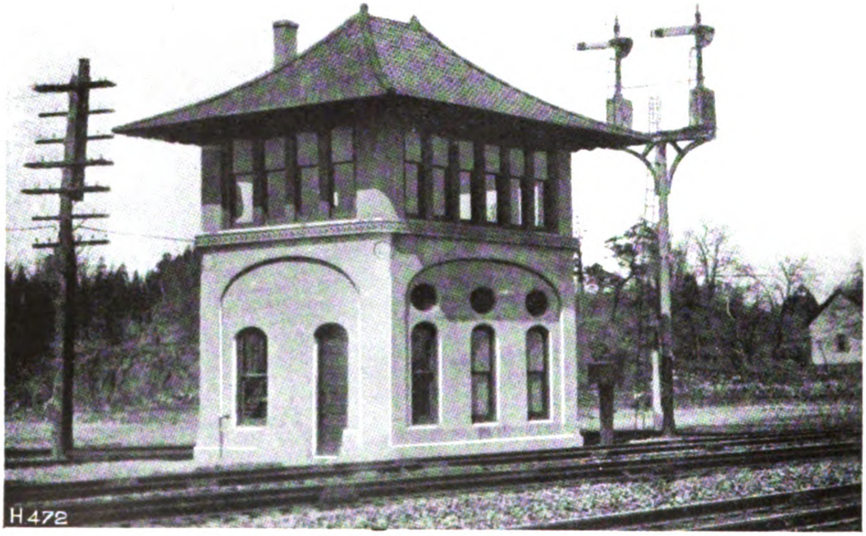


FIG. 15. REINFORCED CONCRETE SIGNAL TOWER.

Reinforced concrete is particularly economical in the case of large roundhouses, when the forms for each unit or stall can be used many times. A good example of this type of structure is the Waterbury roundhouse, which appears in *Fig.* 14, which is designed to include 22 stalls, although at the present time only one portion, comprising 10 stalls, has been erected. Each stall comprises about 8 degrees of the circle and one end of the building is connected to a machine shop. The house consists of four circumferential rows of hooped concrete columns carrying beams and roof slabs of reinforced concrete, while the outer circle is enclosed by a brick wall with large glass windows with concrete sills directly in line with the tracks. The columns, which are over

20 ft. in height, are of square section, 14 in. by 14 in., and are reinforced with six ⅝ in. plain square bars hooped with ⅝ in. round hooping ½ in. pitch.

In connection with roundhouse construction, the subject of turn-table pits is of especial interest, and practically all these are now constructed of concrete. The turn-table is usually supported by a centre pier surmounted by a complete template about 5 ft. sq. by 18 in. thick. The concrete for the pier itself may be mixed in the proportion of 1 part Portland cement to 3 parts sand and 6 parts broken stone, and for the template in the proportion of 1 : 1 : 2. The floor of the pit usually consists of about 4 in. concrete (1 : 2 : 4) laid on 8 in. of well tamped cinders, while the circular rail is carried on a seat of 1 : 3 : 6 concrete, resting on a foundation 5 ft. wide by 4 ft. high.

SIGNAL TOWERS.

The temporary structures used for this class of building are being superseded almost without exception by concrete buildings of a permanent nature, which in many cases have been designed on very artistic lines. The signal tower illustrated in *Fig.* 15 is a typical example, and with the exception of the roof, which is of tile on wooden rafters, it is of concrete construction throughout. The foundation and both exterior and interior walls are of plain 1 : 3 : 5 gravel concrete, while the floors are of 1 : 2 : 4 gravel concrete, reinforced with No. 16 2½-in. expanded metal.

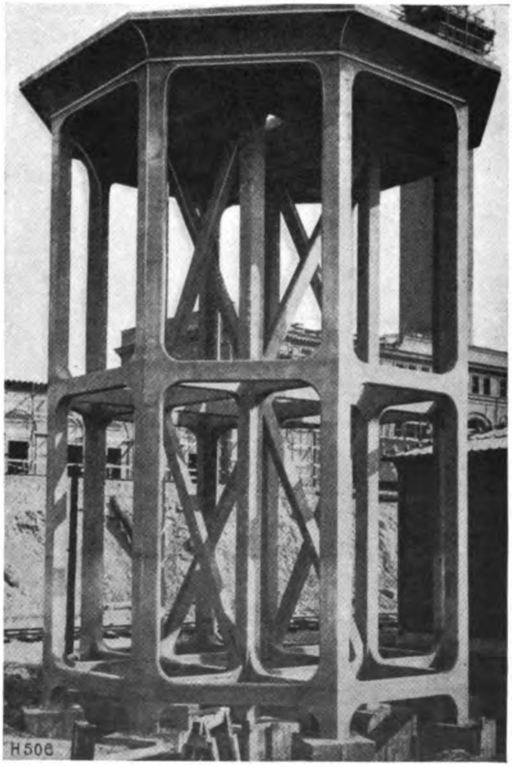


FIG. 16. WATER TANK SUPPORT.

WATER TANK SUPPORTS.

Reinforced concrete has been much used in the construction of water tank supports and its strength, rigidity and resistance to fire and decay render it very suitable for this class of work. A good example is that of the water tank support at Waterbury, N.Y.N.H. and H. Rly., illustrated in *Fig.* 16, which is octagonal in form and 30 ft. 9 in. wide, with the platform carrying a 55,400-gallon wooden tank 40 ft. above the ground line. The method of reinforcing the supporting columns presents a rather unique and interesting feature, consisting as it does of two 95-lb. third rails placed back to back and riveted every 3 ft., making a section in the form of a star strut. The platform, which is 9 in. thick, is reinforced with ½-in. corrugated bars at 4-in. centres in both directions, while the beams and diagonal braces are reinforced with ⅞-in. corrugated bars, bent and hooked as necessary. Concrete for the support was mixed in the proportions of 1 part Portland cement to 2 parts sand and 4 parts screened gravel.

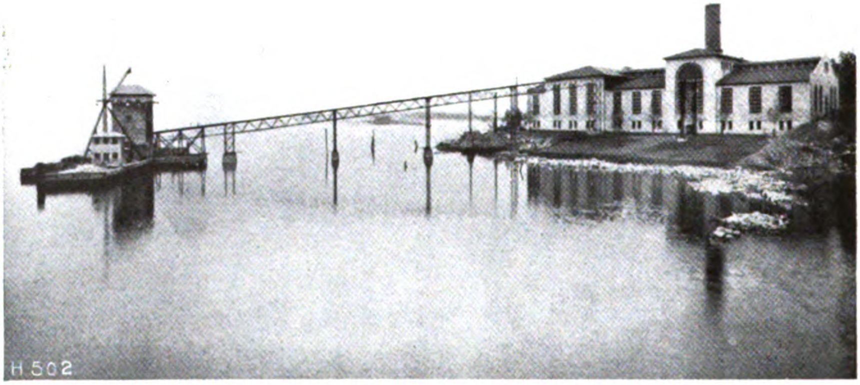


FIG. 17. POWER-HOUSE AT COS-COB.

BUMPING POSTS.

A bumping post, to ensure safety against rotating or breaking down under constant buffing, must be constructed so as to be anchored in the earth direct rather than be attached to the track itself. By the use of concrete, bumping posts can be constructed economically so as to meet the conditions of stability and permanence.

POWER STATIONS.

The construction of a large number of power stations has become necessary during recent years, owing to the electrification of many railway systems, and concrete has been extensively adopted on account of its fire-resisting character, resistance to vibration and freedom from deterioration. The power-house illustrated in *Fig.* 17 is located at Cos-Cob on the Miames River, about one mile from Long Island Sound. The interior is divided into a turbine-room 60 ft. wide by 112 ft. long, with a switch board occupying an additional space of 25 ft. by 110 ft. and a boiler-room 160 ft. long by 110 ft. wide. The foundations, column footings and walls up to the water-table are monolithic concrete mixed in the proportions of 1 part Portland cement, 3 parts sand and 5 parts 2-in. crushed granite. For the water-table, window arches, coping and window-sills monolithic blocks are used made of concrete composed of the same proportions as the other monolithic work. The walls above the water-table are of hollow blocks 10 in. by 12 in. by 24 in., composed of a mixture of 1 part cement, 3 parts sand and 3 parts 1$\frac{1}{4}$-in. crushed granite, faced on the exterior surface with a mixture of 1 of cement to 2 of sand, and where the inner surface of the wall is exposed, with a mixture of 1 part cement to 4 parts sand. All the window lintels were cast in position and consist of 1 : 3 : 5 concrete reinforced with two $\frac{3}{4}$-in. trussed bars. In designing the structural features of the building, the following live loads per sq. ft. were used: Coal bin floor, 550 lb.; engine-room and gallery floors, 400 lb.; boiler-room floor, 340 lb.; fan-room floor, 200 lb.; and roof, 30 lb. The columns in the boiler-room are of structural steel, but all other columns in the building are composed of concrete blocks made by filling the cored air spaces of the hollow blocks with concrete of the same mixture as the blocks themselves. Over the turbine-room, where there are no steel columns, the steel roof trusses are carried by the concrete block wall, the blocks being solid for several courses below the trusses to properly distribute the load, and over the boiler-room the trusses are supported by the walls and the interior steel columns.

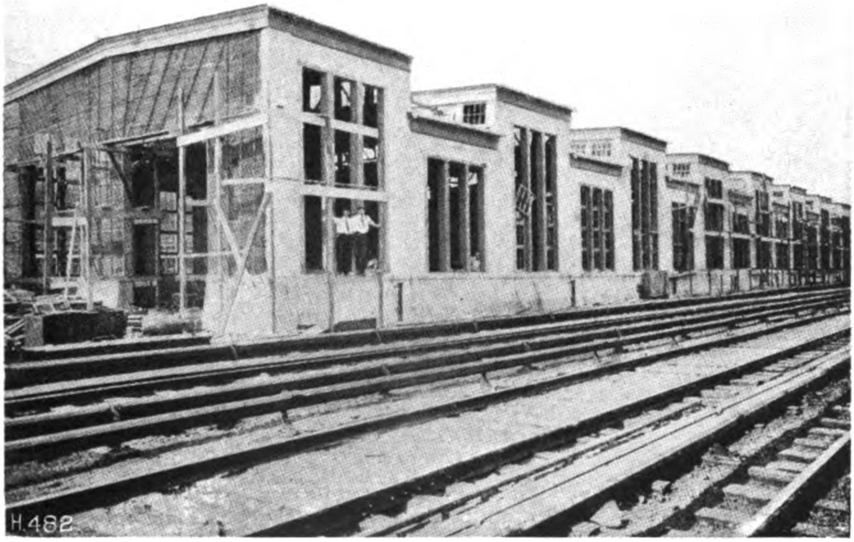


FIG. 18. CARSHOPS BUILT OF REINFORCED CONCRETE.

SHOPS AND WAREHOUSES.

The same advantages which reinforced concrete possesses over other materials for the construction of power-houses are equally enjoyed by it as a material for shops and warehouse buildings for railway purposes, and an example is shown in *Fig.* 18, which is a photograph of the Mott Haven car shops, N.Y.C. and H.R. Rly. These shops are 250 ft. long, 45 ft. 10 in. wide, and, as will be seen from the illustration, they are built in alternate high and low bays, the former 25 ft. high and the latter 19 ft. 4 in. As windows are provided in each side of the high bays above the roof of the low ones this construction takes the place of the ordinary saw-tooth roof. In general, the buildings consist of 2½-in. cement mortar curtain-walls reinforced with truss metal lath, No. 28 gauge, resting on a concrete foundation wall rising 4 ft. above the ground level. The roof is carried on light-angle trusses supported by I beam columns placed every 16 ft. 8 in. at the division between the adjoining high and low sections. Between the columns and window frames steel girts are placed to form a support for the truss metal lath reinforcement of the walls. The metal lath was kept in position and held rigidly by means of temporary 1-in. by 1-in. angles spaced about 2 ft. apart. The mortar, which was mixed in the proportion of 1 part Portland cement to 3 parts sand, was applied in the same manner as plaster for an ordinary wall.

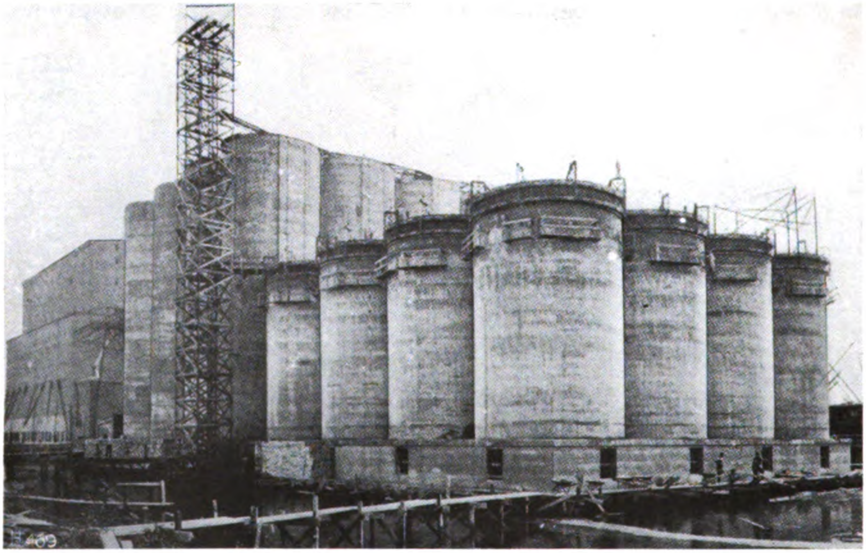


FIG. 19 REINFORCED CONCRETE GRAIN ELEVATOR.

GRAIN ELEVATORS.

The ideal grain elevator must possess the all-important and essential qualities of being absolutely proof against fire, water or dampness, dust and vermin, and for this reason reinforced concrete is especially adapted. These elevators may be grouped into two classes, according to the arrangement of the bins and elevating machinery—viz., elevators which are self-contained, with all the storage bins in the main elevator or working house, and elevators consisting of a working house which contains the elevating machinery and storage bins connected with the working house by conveyors. Reinforced concrete elevators are commonly built of the latter type with a working house that is generally rectangular in shape, with either square or circular bins connected with the independent storage bins, which are usually circular. The photograph in *Fig.* 19 illustrates a grain elevator being constructed. In elevators of this type the storage bins are reinforced both horizontally and vertically. The horizontal reinforcement is either single when it is placed in the centre of the wall or double when the bars are placed near the surface. This reinforcement may be continuous, rising from the bottom to the top as a spiral, in which case high steel is generally used, or it may be placed in separate rings. The vertical reinforcing bars are equally spaced and are wired or clamped to the horizontal rods, at intersections. The horizontal reinforcement is generally designed to take all the tensile stresses resulting from the pressure of the grain while the vertical reinforcement carries the load between the horizontal reinforcement and takes its proportion of the vertical load. The walls have a negative bending moment at the points of horizontal reinforcement and a positive bending moment half way between the horizontal reinforcement. The pressure on any horizontal section equals the weight of the wall plus the weight of the grain carried by the walls, and this pressure is carried by both the concrete and the steel.

STORAGE RESERVOIRS.

The advent of power plants into the sphere of railroad engineering renders it necessary to construct storage reservoirs to supply these plants with water, and here, again, has reinforced concrete been extensively adopted. These reservoirs are most economically built of circular form and all the tensile stresses must be taken by the steel hoops. In building water tanks the materials for the concrete must be very carefully proportioned in order to give a watertight wall, and the stone must be of such size that a good surface can be easily obtained. The proportions used to resist percolation of water usually range from 1 : 1 : 2 to 1 : 2½ : 4½, the most common mixture being 1 : 2 : 4. The concrete should be mixed so that it will entirely cover the reinforcing metal and flow against the form, and it is absolutely essential that the concreting for the entire tank should be done in one operation, or else that the surface be specially prepared and treated to make watertight joints.

DOCKS.

Inasmuch as practically every railroad system owns valuable water front the question of dock construction is an important one. In the tropics, where the waters are infested with limnoria and teredos, which destroy a wooden pile in a few years, and where the very atmosphere itself eats away unprotected wooden and steel structures, reinforced concrete is especially adapted to the construction of wharves and warehouses. Practically all the docks of any magnitude now being constructed in South and Central America and the Philippines are designed as entire concrete structures. The Almirante wharf of the Changninola Railway at Bocas del Toro, Panama, illustrated in *Fig.* 20, is an interesting example of this type of construction. It is approximately 700 ft. long and 54 ft. wide and is connected to the mainland by a creosoted timber trestle approach about 800 ft. in length. As the purpose for the wharf is the loading of bananas on to the outgoing and the temporary storage of general merchandise received from the incoming steamers, the front of the wharf for a distance of 23 ft. is open to allow the free use of automatic loading machines, while the remainder is covered with a steel storage shed open 6 ft. from the bottom in the rear and 14 ft. in the front. The wharf consists of a series of reinforced concrete columns supporting a system of main girders and cross beams, which in turn carry a 7-in. floor slab. The columns rest on wooden piles spaced at 10 ft. centres, protected by a 4-in. covering of concrete. This method of protecting the wooden piles from the attacks of teredos consisted in driving a 2-in. concrete shell—20 in. in diameter at the top and 16 in. at the bottom, reinforced its full length with 4 in. by 12 in. wire cloth—over the wooden pile and into the harbour bottom 2 ft. The shell was then sealed at the bottom with concrete, the water pumped out, and the intermediate space between the shell and the pile filled with concrete to the level of the top of the shell, which was about 2 ft. above the top of the pile and 1 ft. above high water. The shells were made in lengths varying from 32 ft. to 12 ft., according to the depth of water, and were composed of concrete mixed in the proportions of 1 part Portland cement to 2 parts of crusher dust to 3 parts of ½-in. broken stone, and the filling consisted of concrete mixed in the proportions of 1 : 2 : 4.

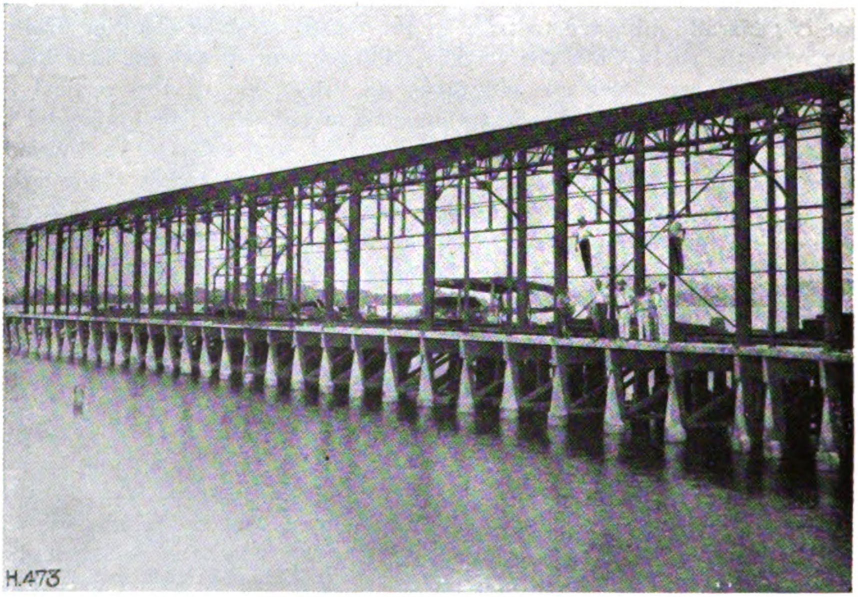


Fig. 20. Wharf at Bocas del Toro, Panama.

In constructing the columns, girders and beams a mixture of 1 of cement, 2 of sand and 2 crusher dust to 3 of 1-in. broken stone was used and for the floor slabs a mixture of 1 : 2 : 1 : 3 of the same materials. The reinforcing rods for the columns were embedded 4 ft. in the filling between the shells and the piles and were carried up through the main girders and into the floor slabs, thus securely tying together the entire structure. For the columns, main girders and railway beams $\frac{7}{8}$-in. round rods were used for reinforcing and for the floor slabs $\frac{1}{2}$-in. round rods.

TUNNELS.

One of the most important uses of both plain and reinforced concrete is in the construction of tunnels, and the expensive and dangerous maintenance work which is necessary with brick-lined tunnels is practically eliminated by the use of concrete.

Fig. 21 shows the Bergen Hill tunnel, which is 30 ft. wide in the clear and 23 ft. 5 in. high from the base of the rail to the crown of the roof arch, with a concrete lining of a minimum thickness of 2 ft. The length is 4,280 ft.

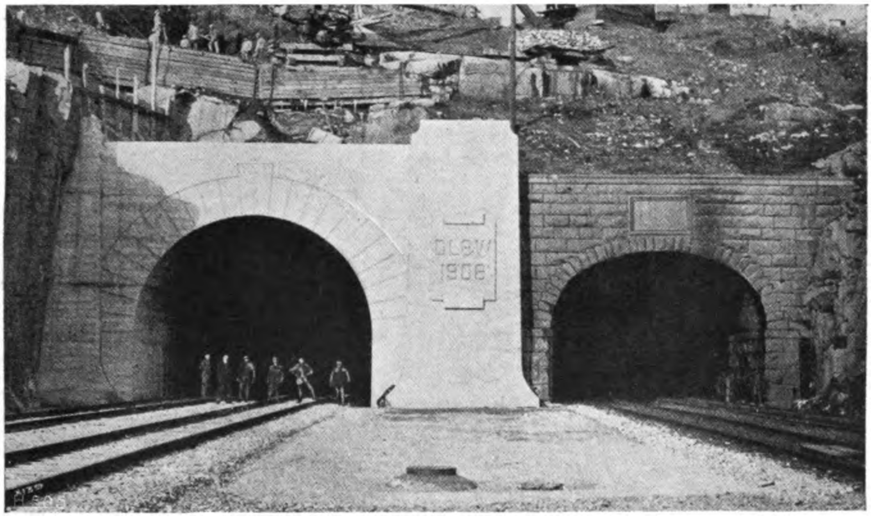


FIG. 21. ENTRANCE TO OLD AND NEW BERGEN HILL TUNNELS.

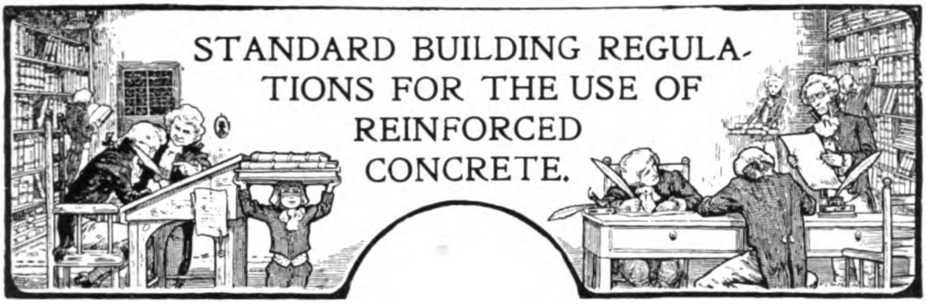
and it is connected to the old tunnel, which is immediately alongside at two points. The comparison between these two tunnels in the question of maintenance has shown a very great advantage in the use of concrete.

RAILWAY SLEEPERS.

One of the most serious and perplexing questions which confront the railway engineer is the problem of dealing with railway sleepers. As evidence of this, during one year the railways of the United States of America use, approximately, 118,000,000 sleepers, a very large percentage of which are renewals. This means a great strain on the rapidly decreasing supply of timber, which is becoming high in price and not always good in quality, with the result that a substitute is required, and this fact has led to experiments with concrete sleepers of different types. While none of these have been tested long enough under heavy and high-speed traffic to warrant selection as a proper substitute for wooden sleepers under all conditions, the success of some of the sleepers tested has been great enough to convince railway engineers who have given the most study to the subject that a properly reinforced concrete sleeper with proper fastenings is a practical and economical one, at least for tracks where the speed is low and where conditions are adverse to the life of wood or metal. There is no question that concrete sleepers are eminently suitable and economical for use in yards and sidings, and that there is an enormous place for their introduction into this field alone. Illustrations of reinforced concrete sleepers have appeared on many occasions in our columns, and we need not reproduce these in this article.

TELEGRAPH POLES.

We have on more than one occasion dealt with the advantages of reinforced concrete for telegraph poles, and there is no doubt that this material is specially adapted to work of this kind. They have been extensively used in the United States, Germany, Denmark, and Switzerland, and we hope that we shall not be slow to follow, as their application would mean a considerable saving in expense and their reliability and low maintenance charges should certainly commend themselves to the authorities concerned.



STANDARD BUILDING REGULATIONS FOR THE USE OF REINFORCED CONCRETE.

We think a copy of the amended building regulations proposed at the recent Convention of the National Association of Cement-users of America should be very interesting at this stage, and we are therefore presenting it in full.—ED.

THE following is the amended code which was voted on at the Convention of the National Association of Cement Users held in Chicago in February last, and which has been sent out for letter ballot.

1. The term "Reinforced Concrete" shall be understood to mean an approved concrete which has been reinforced by metal in some form so as to develop the compressive strength of the concrete.

CLASS OF BUILDINGS.

2. Reinforced concrete may be used for all classes of buildings if the design is in accordance with good engineering practice and stresses are figured as indicated in these regulations.

HEIGHT.

3. There shall be no limit upon the height of buildings of reinforced concrete except as limited by the requirements in these regulations.

PLANS.

4. Before permission is granted by the Building Department to erect any reinforced concrete building, complete plans, accompanied by specifications, signed by the engineer and architect, must be filed with the Building Department and remain on file for public inspection until the building is completed.

5. The Building Department shall have access to the computations, which shall give the loads assumed separately, such as dead and live loads, wind and impact, if any, and the resulting stresses.

SPECIFICATIONS.

6. The specifications shall state the qualities of the materials to be used for making the concrete, and the proportions in which they are to be mixed.

7. Upon the completion of the building the engineer and architect shall issue, under the approval of the Building Department, signed certificates, to be posted on each floor of the building, stating the safe carrying capacity per square foot.

RECORDS.

8. There shall be kept an exact record of the progress of each operation where the same can be inspected by the Building Department. These records shall show the date of placing of all the concrete and date of removal of the forms, and must be turned over to the Building Department when the building is completed.

WALLS.

9. Reinforced concrete walls may be used in place of brick or stone walls with thickness reduced two-thirds the thickness called for, for brick walls. Curtain walls shall be not less than 4 in. thick.

10. Concrete walls must be reinforced in both directions. The maximum spacing of reinforcing bars shall be 18 in. between centres, reinforcement in both faces of the wall being considered. Total reinforcement shall be not less than one-fourth of 1 per cent.

TILE AND JOIST CONSTRUCTION.

11. Wherever floor constructions are built with a combination of tile or other fillers between joists, the following rules regarding the dimensions and methods of calculations of construction shall be observed. (*a*) Ratio of minimum depth to clear span of joist shall be not greater than one to eighteen. (*b*) Wherever a portion of the slab above the tile-joist shall be considered as acting as a T-beam section, the slab portion must be cast monolithic with the joist, and must have a minimum thickness of at least 2 in. on all spans. Otherwise all regulations applying to T-beams shall apply to tile and joist construction. (*c*) Where the joists are figured as rectangular beams, in accordance with the standard regulations for this type of beams, the slab shall be considered as independent of the structural part of the building. (*d*) Wherever porous tiles or other materials which by their nature will absorb water from the concrete, are used between the joists, care must be taken thoroughly to saturate the tiles, or other materials, with water immediately before the concrete is placed. (*e*) Reinforcement for slabs over joist construction below 30-in. centres need not be closer than 24 in. in each direction.

CEMENT.

12. Only Portland cement shall be used in reinforced concrete structures. Portland cement shall meet the requirements of the Standard Specifications for Cement of the American Society for Testing Materials. (See Standard No. 1 of the National Association of Cement Users.)

13. Tests of cement used in building operations shall be made from time to time under the supervision of the Building Department in accordance with the preceding specifications. No brand of cement which has not met these requirements shall be used.

AGGREGATES.

14. Extreme care shall be exercised in selecting the aggregate for mortar and concrete, and careful tests must be made, where any doubt exists, of the materials for the purpose of determining their qualities and the grading necessary to secure maximum density or a minimum percentage of voids.

15. Fine aggregates shall consist of sand, crushed stone or gravel screenings, passing when dry a screen having ¼-in. diameter holes, and more than 6 per cent. passing a sieve having 100 meshes per lineal inch. It shall be clean, silicious material free from vegetable loam or other deleterious matter.

16. Mortars composed of one part Portland cement and three parts fine aggregate by weight when made into briquets should show a tensile strength of at least 70 per cent. of the strength of 1 : 3 mortar of the same consistency made with the same cement and standard Ottawa sand.

17. Coarse aggregate shall consist of inert material, such as crushed stone or gravel, which is retained on a screen having ¼-in. diameter holes; the particles shall be clean, hard, durable, and free from all deleterious material. The maximum size of the coarse aggregate shall be such that it will not separate from the mortar in laying, and will not prevent the concrete fully surrounding the reinforcement or filling all parts of the forms.

18. The maximum size for reinforced concrete shall be such that all the aggregate shall pass a 1¼-in. diameter ring.

CINDER CONCRETE.

19. Cinder concrete shall not be used for reinforced concrete structures; it may be used for fireproofing. Where cinders are used as the coarse aggregate they shall be composed of hard, clean, vitreous clinker, free from sulphides, unburned coal or ashes.

REINFORCEMENT.

20. Medium steel for reinforcement of concrete shall be made from new billets, and shall conform to the requirements of the specifications for structural steel adopted by the American Railway Engineering and Maintenance of Way Association. The Building Department shall at its option in lieu of this grade of steel accept medium steel meeting the requirements of the manufacturers' standard specifications, provided the Building Department shall be furnished with the results of two tests made originally by the manufacturer—tests being taken from each melt, one for bending and one for tension; and provided further that the contractor furnishing such steel shall furnish such additional bars of all sizes for thoroughly testing by the Building Department.

21. High elastic limit steel shall have (1) an elastic limit of 50,000 lb. to 65,000 lb. per square inch, (2) a minimum elongation in per cent. in 8 in. of 1,000,000 ÷ (ultimate strength), and (3) be capable of cold bending 180 deg. around four diameters without fracture.

MIXING.

22. The ingredients of concrete shall be thoroughly mixed to the desired consistency, and the mixing shall continue until the cement is uniformly distributed and the mass is uniform in colour and homogeneous.

23. Methods of measurement of the proportions of the various ingredients, including the water, shall be used, which will secure separate uniform measurements at all times.

24. ***Machine-Mixing.***—When the conditions will permit, a machine-mixer of a type which ensures the proper mixing of the materials throughout the mass shall be used.

25. ***Hand-Mixing.***—When it is necessary to mix by hand, the mixing shall be on a water-tight platform, and especial precautions must be taken to turn the materials until they are homogeneous in appearance and colour.

26. ***Consistency.***—The materials must be mixed wet enough to produce a concrete of such a consistency as will flow into the forms and about the metal reinforcement, and which, on the other hand, can be conveyed from the mixer to the forms without separation of the coarse aggregate from the mortar.

27. Retempering mortar or concrete, *i.e.*, re-mixing with water after it has partly set, shall not be permitted.

PLACING CONCRETE.

28. Concrete shall be placed in the work immediately after mixing, and deposited and rammed or agitated by suitable tools in such a manner as to produce thoroughly compact concrete of maximum density. No concrete shall be placed until the reinforcement has been placed and firmly secured by wiring or other methods to prevent displacement.

29. The faces of concrete exposed to premature drying shall be kept damp for a period of at least seven days.

30. Before placing the concrete care shall be taken to see that the forms are substantial and thoroughly wetted and the space to be occupied by the concrete free from débris. When the placing of the concrete is suspended, all necessary grooves for joining future work shall be made before the concrete has had time to set.

31. When work is resumed, concrete previously placed shall be roughened, thoroughly cleansed of foreign material and laitance, drenched and slushed with a mortar consisting of one part Portland cement and not more than two parts fine aggregate.

32. ***Placing in Water.***—Concrete should not be placed in water, unless unavoidable. Where concrete must be placed under water unusual care must be taken to prevent the cement from being floated away.

33. ***Freezing Weather.***—Concrete shall not be mixed or deposited at a freezing temperature unless special precautions are taken to avoid the use of materials containing frost or covered with ice crystals, and to provide means to prevent the concrete from freezing after being placed in position and until it has thoroughly hardened.

PLACING REINFORCEMENT.

34. The reinforcement shall be accurately located in the forms and secured against displacement.

JOINTS.

35. ***Reinforcement.***—Wherever it is necessary to splice reinforcement by means of lapping, the length of the lap shall be determined upon the basis of the safe bond stress and the stress in the bar at the point of splice; or a connection shall be made between the bars of sufficient strength to carry the stress. Splices at the point of maximum stress must be avoided.

36. In columns large bars (bars with area equal to 1¼ in. diameter round or larger) shall be properly butted and spliced. Smaller bars may be lapped as indicated in paragraph 35.

37. ***Concrete.***—Reinforced concrete work shall be stopped at such points that the joints will have the least possible effect on the strength of the structure. Footings

shall be cast to their full depth at one operation. (*a*) Columns.—Work in columns shall be stopped at the underside of the lowest projection at the head of the column. (*b*) Beams and Girders.—Construction joints in beams and girders shall be vertical and within the middle third of the span. Any concrete which may run past the bulkheads must be cleared up before the concreting of the next section is started. Where brackets are used, the brackets shall be considered as a part of the beam or girder. (*c*) Slabs.—Construction joints in slabs shall be near the centre of the span. No joint will be allowed between slab and beam or girder.

REMOVAL OF FORMS.

38. Under no consideration shall forms be removed until the concrete has hardened sufficiently to permit their removal with safety.

39. ***Floor Slabs and Beams.***—Forms shall not be removed from floor slabs in less than seven days. Sides of beams may be removed at the same time as the floor slabs, provided original supports under beams and girders are left in place.

40. ***Columns.***—Where original supports remain under beams and girders coming to the columns, the forms shall not be removed from the columns in less than four days.

REMOVAL OF SUPPORTS.

41. ***Beam and Girder Supports.***—The original supports for all beams and girders must remain in place at least ten days, but all beams and girders having more than 30 ft. span from centre to centre of support shall be considered as special cases and shall be subject to inspection of the Building Department before removal of supports. The length of time before the removal of forms shall be increased in all cases and additional time for each and every day that the thermometer registers any time during the day or night below 35° Fahrenheit.

ASSUMPTIONS IN DESIGN.

42. ***Internal Stresses.***—As a basis for calculations for the strength of reinforced concrete construction, the following assumptions shall be made: (*a*) A plane section before bending remains plane after bending. (*b*) The modulus of elasticity of concrete in compression within the usual limits of working stresses is constant. (*c*) In calculating the moment of resistance of beams the tensile stresses in the concrete shall be neglected. (*d*) Perfect adhesion is assumed between concrete and reinforcement. Under compressive stresses the two materials are therefore stressed in proportion to their moduli of elasticity and their distance from the neutral axis. (*e*) The ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete shall be assumed to be 15. (*f*) No allowance shall be made for tension in concrete. (*g*) Initial stress in the reinforcement due to contraction or expansion in the concrete may be neglected. (*h*) In columns the ratio of least diameter to height shall be taken as one-fifteenth. Greater ratios shall be deducted by satisfactory column formulæ.

43. ***Length of Beams and Slabs.***—The span length for beams and slabs shall be taken as the distance from centre to centre of supports, but shall not be taken to exceed the clear span plus the depth of beam or slab. Brackets shall not be considered as reducing the clear span.

44. Length of columns shall be taken as the maximum unsupported length.

45. Where slabs and beams are figured as simple beams the length shall be considered as the clear distance between supports excluding brackets.

LOADS.

46. The dead load shall include the weight of the structure and all fixed loads and forces.

47. The weight of the reinforced concrete shall be taken as 150 lb. per cu. ft.

48. The live load shall include all loads and forces which are variable. The minimum live load for floors and roofs shall be as generally provided by building codes.

49. ***Roof and Floor Loads.***—The roof shall be figured to carry 30 lb. live load per square foot unless otherwise noted.

50. A reduction of live load coming to the column supporting the floor below the roof of 5 per cent. to be allowed and a further reduction of 5 per cent. of the live load of each story below until the total reduction shall amount to 50 per cent. of the live load of any floor, after which all loads shall be figured net to the foundations. These reductions shall not apply to storage warehouses.

51. ***Reduction of Loads.***—No reduction of loads shall be allowed for figuring floor slabs.

52. No reduction of loads shall be allowed for figuring beams.

53. A reduction of 15 per cent. live load may be allowed in figuring the girders, except in buildings used for storage purposes.

54. In assuming the load coming to the columns all beams and girders shall be considered as carrying a net load consisting of 100 per cent. each of live and dead load, subject to the above reductions.

BENDING MOMENTS.

55. Slabs.—The bending moment of slabs uniformly loaded and supported at two sides only shall be taken as $wl^2/8$, where w = unit load and l = span.

56. ***Continuous Slabs.***—For interior slabs overhanging two or more supports the bending moment shall be taken as $wl^2/12$. The reinforcement at the top of the slab over supports must equal that used at the centre.

57. ***Slabs Reinforced in Both Directions.***—Slabs that are reinforced in both directions and supported on four sides and fully reinforced over the supports (the reinforcement passing into the adjoining slabs) may be figured on the basis of bending moments equivalent to wl^2/F for load in each direction. When span under consideration is not continuous, $F=8$; when continuous over one support, $F=10$; when continuous over both supports, $F=12$. The distribution of the loads to be determined by the formula: $r = L^4 \div (L^4 + b^4)$, in which r equals proportion of load carried by the transverse reinforcement, L equals length of span, and b equals breadth of slab.

58. The slab area may be reduced by one-half, as above figured, when the reinforcement is parallel to and not farther from the supports than one-quarter of the shortest side. The reinforcement spanning the shortest direction shall be below the reinforcement spanning the longer direction, and shall not be further apart than two and a half times the thickness of the floor, including the finish.

59. ***Simple Beams.***—The bending moment of beams supported at the ends only shall be figured as of simple beams.

60. ***Partially-Restrained Beams.***—Beams supported at one end and continuous at the other to be figured partially restrained with a bending moment of eight-tenths that of a simple beam. When the over-all vertical distance of the tension members is greater than one-sixth of the total depth of the beam the stresses in each member shall be computed in proportion to the distance from the neutral axis.

61. Beams supporting rectangular slabs reinforced in both directions shall be assumed to take the following load: The beams on which the shortest sides of the slab rest shall take the load of that portion of the slab formed by the isosceles triangle having this side as its base and half this side as its height. The load from the remaining portion of the slab shall go to the beams on which the long side of the slab rests.

62. ***Continuous Beams.***—When beams or girders are continuous over two or more supports, the interior beams may be considered as partially restrained, and the bending moments at the centre and support figured as two-thirds that of a simple beam, unless the concrete at the bottom of the beam at the support shall by this consideration receive excess compression.

63. ***T-Beams.***—In beam and slab construction, an effective metallic bond should be provided at the junction of the beam and slab. When the principal slab reinforcement is parallel to the girder, transverse reinforcement shall be used extending over the girder and well into the slab.

64. Where adequate bond between slab and web of beam is provided, the slab may be considered as an integral part of the beam, but its effective width shall not exceed one-sixth of the span length of the beam on either side of the beam, nor be greater than six times the thickness of the slab on either side of the beam. Measurements from the edge of the web.

65. In the design of T-beams acting as continuous beams, due consideration should be given to the compressive stresses at the support at the bottom of the beam.

WORKING STRESSES.

66. Concrete composed of materials meeting the requirements of these regulations, mixed in proportion of one part of cement and six parts of aggregate (fine and coarse), shall develop a compressive strength of 2,000 lb. per sq. in. in 28 days when tested as 8-in. diameter cylinders 16 in. long under laboratory conditions of manufacture and

storage, using the same consistency as is used in the field. When the proportion of cement is increased, using the best quality of aggregates, an increase may be made in all working stresses proportional to the increase in compressive strength at 28 days, as determined by actual tests, but this increase shall not exceed 25 per cent. On this basis the following working stresses shall be allowed in construction :—

67. Bearing compression, 650 lb. per sq. in.

68. Compression in extreme fibre, 650 lb. per sq. in.; with increase of 15 per cent. near supports in continuous beams.

69. Axial compression in columns without hoops, 450 lb. per sq. in. and 6,750 lb. per sq. in. on vertical reinforcement.

70. Axial compression in columns with 1 per cent. of hooping, 540 lb. per sq. in., and 6,750 lb. per sq. in. on vertical reinforcement.

71. Axial compression in columns with 1 per cent. hooping and 1 to 4 per cent. of vertical reinforcement, 650 lb. per sq. in. on the concrete and 9,750 lb. on the vertical reinforcement. Where it becomes necessary or desirable to use vertical reinforcement of size equal to or larger than a section 1¼ in. round bar, the ends of all longitudinal reinforcing members must be finished to a plain bearing surface and provision shall be made for properly-holding reinforcing members in line, and while the concrete is being deposited. The bars in the base of such columns shall bear on a plate or casting, or shall be enlarged so as to reduce the bearing stress at the bottom to the stress given in paragraph 67. In lieu of plate an enlargement for bearing the stress may be distributed to the footing by means of dowels with planed upper ends, length of the dowels being sufficient to distribute the stress by means of the bond of the dowel. In the footing the concrete bond stress to be as given in paragraph 74. The footings supporting columns where hooping and vertical reinforcement is used shall be enlarged to at least six inches on each side of the column, measurements being taken from the centre of the hooping. Bars composing longitudinal reinforcement shall be straight and shall have sufficient lateral support to be securely held in place until the concrete is set. The clear spacing of bands or hoops shall not be greater than one-fourth the diameter of the enclosed column. Adequate means must be provided to hold bands or hoops in place so as to form a column, the core of which shall be straight and well centred. Bending stresses due to eccentric loads must be provided for by increasing the section until the maximum stress does not exceed the values above specified.

72. Compression on columns reinforced with structural steel units which thoroughly encase the concrete core, 540 lb. per sq. in. on the concrete and 8,100 lb. per sq. in. on the structural steel.

73. ***Web Stresses.***—In calculating web reinforcement the concrete shall be considered to carry 40 lb. per sq. in., the remainder to be provided for by means of reinforcement in tension. Members of web reinforcement shall be embedded in the compression portion of the beam, so that adequate bond strength is provided to develop fully the assumed strength of all shear reinforcement. They shall not be spaced to exceed three-fourths of the depth of the beam in that portion where the shearing stresses exceed the allowable shearing value of the concrete. Web reinforcement, unless rigidly attached, shall be placed at right angles to the axis of the beam and looped around the extreme tension member.

74. Bond between plain bars and concrete, 80 lb. per sq. in. of surface of bar; where adequate mechanical bond is provided the stress shall not exceed 150 lb. per sq. in. of surface of bar.

RATIO OF MODULI.

75. The ratio of modulus of elasticity of concrete to steel shall be considered as 1 to 15.

76. The allowable tensile stress in reinforcement to be 16,000 lb. per sq. in. for medium steel and 20,000 lb. per sq. in. for high elastic limit steel with adequate mechanical bond.

77. The compressive stress in the steel reinforcement to be fifteen times the allowed compression in concrete in which the steel is embedded.

FIREPROOFING.

78. The main reinforcement in columns shall be protected by a minimum of 2 in. of concrete, reinforcement in girders and beams by 1½ in. and floor slabs by 1 in.

TESTS ON REINFORCED CONCRETE CONDUCTED IN GREAT BRITAIN.

(PART VIII.)

The first seven articles of this series appeared in our May, September, November, January, February, March and April numbers respectively. The following particulars of tests are now presented, and further articles will appear from time to time.—ED.

UNITED KINGDOM FIREPROOFING COMPANY'S TESTS.

A test on a floor slab in the Hillhead Exchange, Glasgow, constructed by the United Kingdom Fireproofing Co., Ltd., for the National Telephone Co. (Mr. Leonard Stokes, F.R.I.B.A., and Mr. Colin Menzies, associated architects), was conducted on June 12th, 1908. The slab measured 18 ft. 6 in. long from front wall to centre of main steel girder and 14 ft. 6 in. wide from centre to centre of supporting side girders, and was calculated to carry a live load of 1¾ cwt. per sq. ft. The thickness of the concrete was 7½ in. over all. The load was applied by means of pig-iron on a strip 8 ft. wide in the centre of the longest span, measuring 116 sq. ft. in superficial area. The deflections were read by means of a simple lever apparatus placed at the centre of the span, which multiplied the actual deflections by four and recorded them on an indicator placed clear of the slab under test. The concrete of which the floor was made was composed of 1 part Portland cement to 6 parts aggregate, this latter consisting of 2 parts sharp sand to 4 parts hard burned clinker broken to pass about a ¾-in. mesh sieve. The floor was concreted on May 7th, and was thus 5 weeks old when tested. The following deflections were observed between 11.30 a.m. and 12.55 p.m. :—

Total Applied Load in lbs.	Actual Deflection in in.
9,296	0
19,040	3/32
29,344	7/32
38,304	3/16
47,208	9/32

On the removal of the load the indicator returned to zero, and there was no evidence of the concrete cracking or of deterioration of any kind.

Other tests were carried out on October 10th, 1908, at the Salford Royal Hospital, of which Mr. John Ely, F.R.I.B.A., is the architect. One was on a solid reinforced concrete floor slab to a corridor of 5 ft. 6 in. span. The thickness was 3½ in. over all, and the reinforcement consisted of ⅝ in. diameter steel rods at 14½ in. centres. The area loaded was a 3 ft. width right across the span. The floor was made with concrete composed of 6 parts breeze to 1 of Portland cement. The floor was designed to carry a safe super load of 80 lb.; the test load was 240 lb. per sq. ft., which gave a deflection of 1/16 in. The deflection was measured by a lever arm multiplying the actual deflection by three. The second floor was in one of the rooms, and was of hollow sound proof construction, consisting of breeze concrete tubes 7 in. deep by 3 ft. wide, with concrete beams moulded *in situ* between 3 in. wide, thus making 3 ft. 3 in. centres, with a concrete fill composed of 6 parts broken brick to 1 part Portland cement over all, making the total depth 8 in. The span was 12 ft. between lintel at one end and wall at other. The area load was 6 ft. by 6 ft., each end of the loaded portion being 3 ft. from the support. The reinforcement in each beam consisted of four ⅜ in. diameter steel bars. The floor was designed to carry a safe super load of 80 lb. per sq. ft. The test load was 240 lb. per sq. ft. of area loaded. and the actual deflection was 1/16 in.; this deflection was recorded by a lever arm multiplying actual deflection by three.

A test on a solid floor constructed at Epps' Cocoa Factory, by the United Kingdom Fireproofing Co., Ltd. (Mr. E. T. Hall, V.P.R.I.B.A., architect), was also conducted in 1908. The span was 9 ft., the thickness of floor 4½ in., composed of 6 parts breeze concrete to 1 part Portland cement, with 2 in. of granolithic finish over. The reinforcement consisted of ⅝ in. diameter bars at 10½ in. centres. The area loaded was a 10 ft width right across span. The floor was designed for an inclusive load of 336 lb. per sq. ft., and the test load applied was 448 lb. per sq. ft., which gave a deflection of ⅛ in.

A floor constructed by the United Kingdom Fireproofing Co., without centering, at the London & Joint Stock Bank, Kingsway, London (Messrs. R. Creese, Harrison & Sons, architects), was tested in 1908, and consisted of terra-cotta tubes 1 ft. 6 in. wide and 7 in. deep resting between the concrete beams, 2 in. wide at the top and splayed out on the under side, cast previously at the firm's yard (these beams, therefore, being at 1 ft. 8 in. centres), and a concrete filling over all, making the total depth 10 in. The reinforcement in each beam consisted of one ⅞-in. diameter rod and two $\frac{5}{16}$-in. diameter rods, the first mentioned being cranked up at the ends to reinforce against shear stresses. The composition of the concrete was composed—in the beams—of 6 parts breeze to 1 part of cement, while in the filling over the tubes and beams it was proportioned 4 parts of broken brick to 1 of cement. The clear span of the bay tested was 9 ft., and the area loaded was 17 ft. by 9 ft. The floor was designed for an inclusive load of 1¼ cwt. per sq. ft., and was tested with 1½ cwt. per sq. ft. super load. The deflection recorded was $\frac{1}{32}$ in.

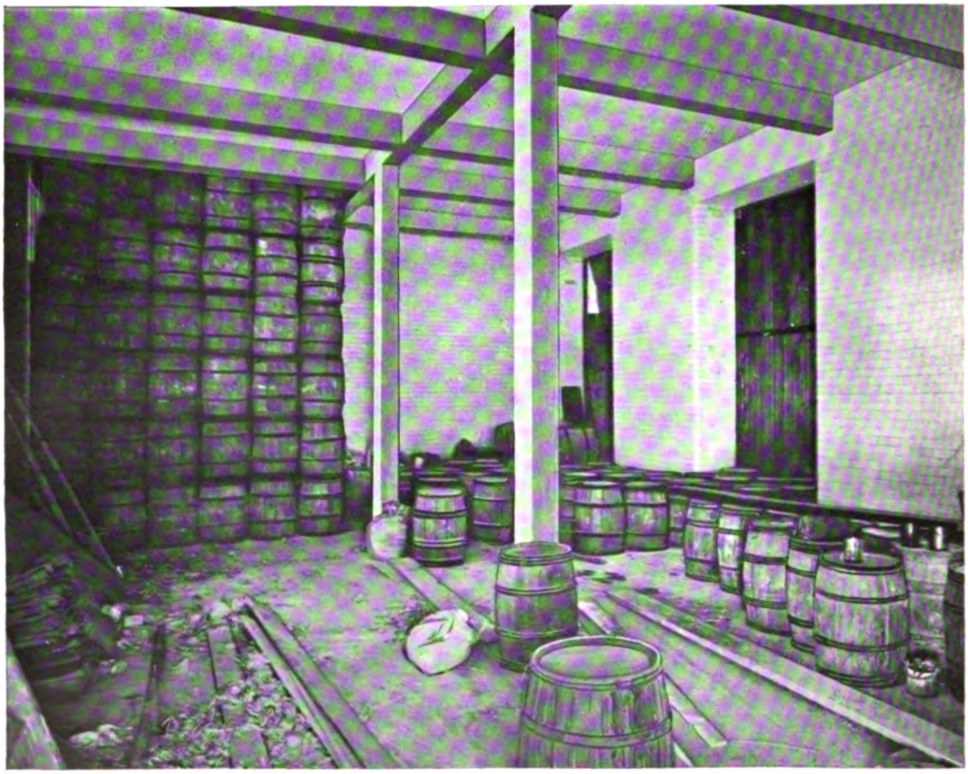


FIG. 50. TEST OF FLOOR AT EPPS' COCOA FACTORY.

An experimental test of a somewhat similar floor was carried out on April 8th, 1908, at the works of the United Kingdom Fireproofing Co. at Alperton. The floor was one of 24 ft. clear span, and was 12 in. deep. The construction is shown in *Fig* 53. Two identical floors, each 12 ft. wide, were constructed in the last week of December, 1907. One, as a preliminary test, was loaded with a distributed load of 85,000 lb. about the beginning of March. This caused some deflection, and at the day of the test was removed on to the other floor, when it was found that nearly all the deflection was recovered. The floor was made of granite concrete proportioned 4 parts crushed Leicestershire granite, 1 part sharp sand, and 1 part Portland cement, of "Ferrocrete" brand, supplied by the Associated Portland Cement Manufacturers (1900), Ltd. The tubes were of similar concrete, and measured 3 ft. wide by 7 in. to 7½ in. deep and 12 in. long, their thickness varying between 1¾ in. and 2 in. The floor rested upon blue brick piers well strutted to prevent overturning The section of each reinforcement was 1¾ in. by ¼ in., so that the total section of steel in each beam was 5¼ sq. in. The material was mild steel having a tensile strength of about 28 tons ultimate. The reinforcements were cranked up at various places to resist diagonal tension stresses. The floor was designed to carry a super load of ¾ cwt., with a factor of safety of 4. The floor was given 1 in. camber, and the centering consisted of members strutted from below placed under the beams only, the tubes between forming a permanent centering. The deflection was read on the sliding scale as each layer of bricks comprising the load was applied. These bricks varied in weight, and the loads recorded are therefore only approximate, although an effort was made to obtain the average weight fairly closely. The load was at first applied on a centre strip 7 ft. 6 in. wide across the clear span. The deflections under this partially distributed load were as follows :—

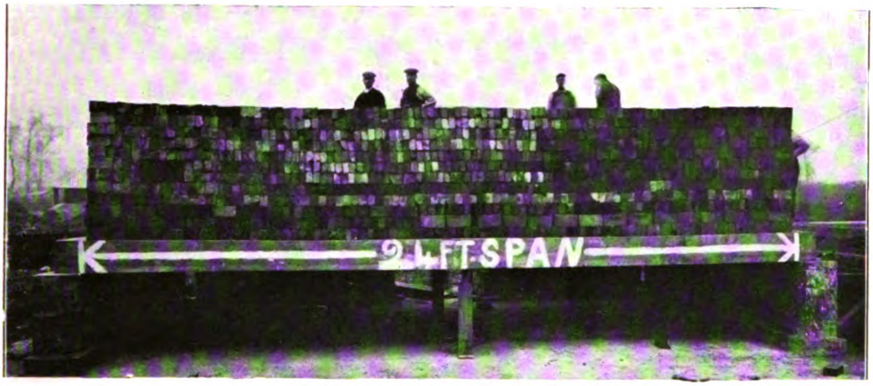


FIG. 51. THE FLOOR UNDER TEST.
TEST AT THE U.K. FIREPROOFING COMPANY'S WORKS, ALPERTON.

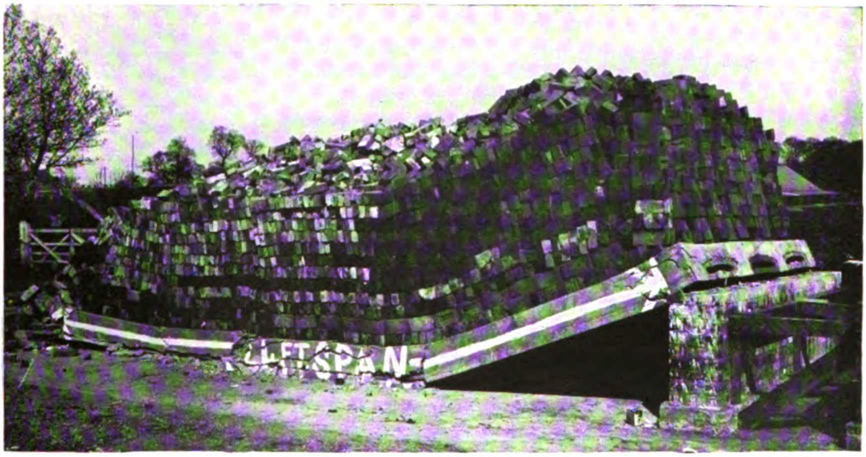


FIG. 52. THE FLOOR AFTER THE COLLAPSE.
TEST AT THE U.K. FIREPROOFING COMPANY'S WORKS, ALPERTON.

Total Load Distributed. lb.	Centre Deflection at Middle. in.	Centre Deflection at Side. in.
8,000	$\frac{1}{8}$	$\frac{1}{8}$
16,000	$\frac{3}{16}$	$\frac{3}{16}$
24,000	$\frac{1}{4}$ bare	$\frac{1}{4}$ bare
32,000	$\frac{5}{16}$	$\frac{5}{16}$
40,000	$\frac{7}{16}$	$\frac{13}{32}$
47,600	$\frac{9}{16}$	$\frac{17}{32}$
55,200	$\frac{11}{16}$	$\frac{5}{8}$
62,800	$\frac{7}{8}$	$\frac{3}{4}$
70,400	1	$\frac{7}{8}$
78,000	$1\frac{1}{8}$	1
85,600	$1\frac{5}{16}$	$1\frac{1}{8}$
93,000	$1\frac{1}{2}$	$1\frac{5}{16}$

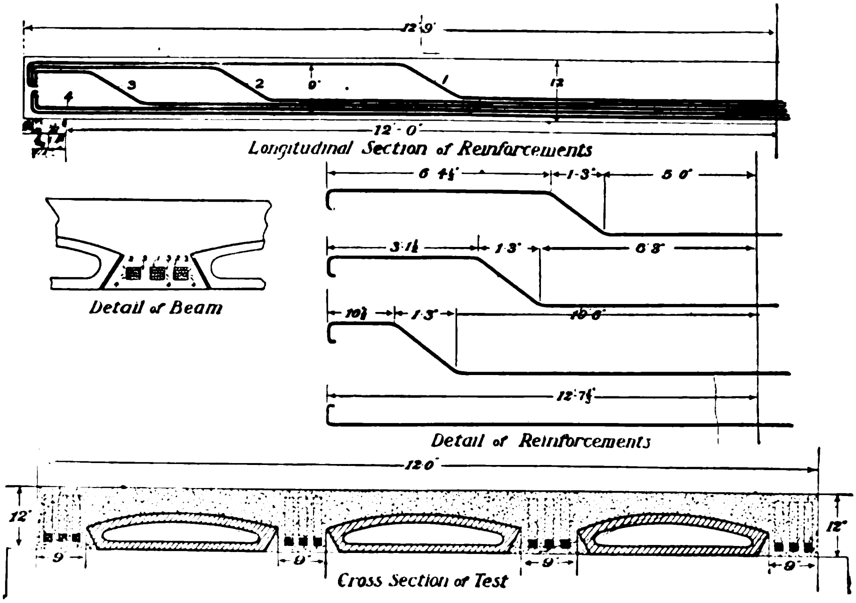


FIG. 53. GENERAL DETAILS OF FLOOR TESTED.
TEST AT THE U.K. FIREPROOFING COMPANY'S WORKS, ALPERTON.

After this it was decided to load the whole area of the floor with bricks, and therefore the bricks were laid on the side portions to a height of 12 courses—*i.e.*, to the same height as the middle portion had been carried. At this point the total load upon the floor was 127,500 lb., the deflection in the middle being $2\frac{1}{4}$ in., and the deflection at the sides 2 in. Bricks were now thrown on the top and centre of the load without any attempt at stacking. The deflection gradually increased to $3\frac{3}{16}$ in. and $2\frac{3}{4}$ in. at the sides after the total quantity of bricks available had been placed upon the floor, weighing in all about twelve tons. The loading was discontinued about 4.30 p.m., and during the night the floor gave way without any extra load being added. A few diagonal cracks were developed near the supports, but the shear reinforcement appeared to act satisfactorily. Cracks developed on the soffit of each of the beams, but these were not at all wide. A certain amount of arching, no doubt, occurred in the load, but the bricks were stacked in such a manner that the layers did not bond very much with each other.

SIDEOLITH TEST.

A beam reinforced with section of "skeleton steel" was tested on June 17th, 1909, at Birmingham University for Messrs. Sideolith.

The beam was 10 ft. by 9 in. by 10 in. deep, and made of concrete composed of 1 part cement, 2 parts sand, and 3 parts aggregate graded from ¾in. downwards, reinforced with one "skeleton" (Section F., see *Fig.* 54) weighing 38 lb. It was tested on a span of 9 ft., supported on rounded steel knife edges and loaded in the centre through an iron plate 5 in. wide with two thicknesses of millboard packing. The load was applied vertically, and the beam carried its own weight in addition. The result was as follows:—

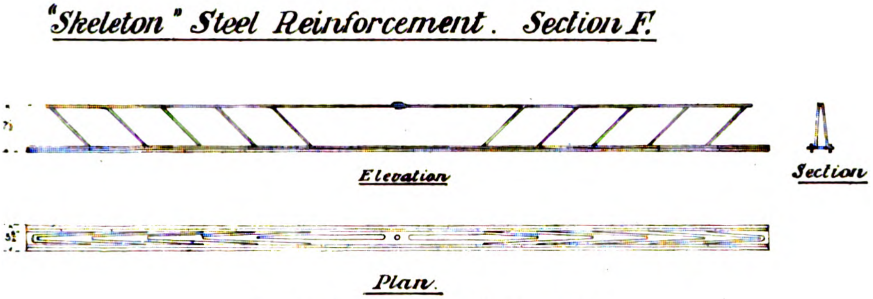


FIG. 54. SKELETON STEEL REINFORCEMENT.

No. of Beam	Mark on Beam	Length	Weight	Load when first Crack was noticed	Breaking Load
4	H.S.	10 ft.	860 lb.	10,820 lb.	10,820 lb.

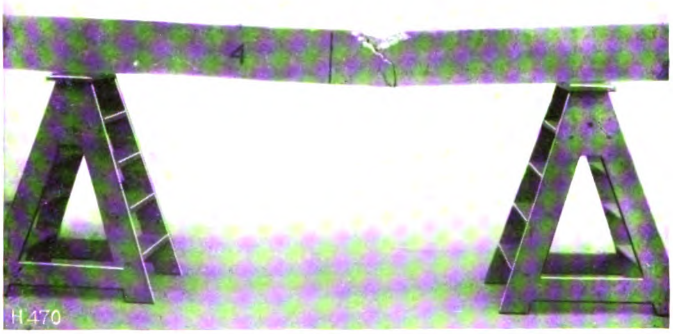
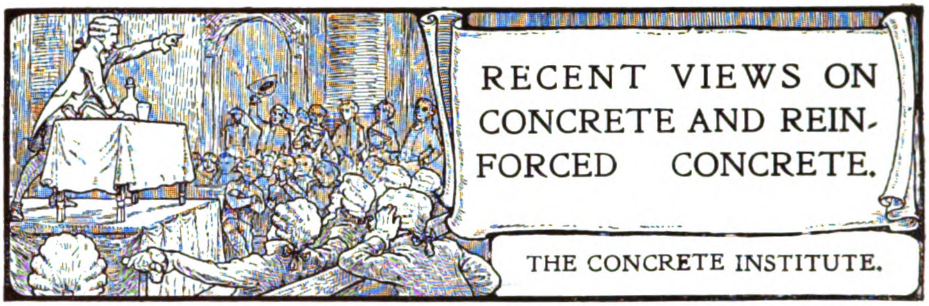


FIG. 55. SIDEOLITH BEAM AFTER TEST.

It will be observed that no crack was noticed until the breaking load was reached.

This beam was one of a series of tests with beams variously reinforced with other methods, and gave a better result—viz., 10,820 lb. as against 10,280 lb. for a similar beam reinforced with 52 lb. of metal, this latter beam also showing signs of cracking at 6,160 lb. *Fig.* 55 shows the state of the beam when removed from the testing machine.

(*To be continued.*)



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

A MEETING of the Concrete Institute was held at the Royal United Service Institution, Whitehall, S.W., on April 21st.

The paper on this occasion was read by Mr. Sidney H. Chambers, Engineer and Surveyor to the Hampton Urban District Council, and we are giving a summary of it and of the discussion which followed.

THE EFFECTS OF SEWAGE AND SEWAGE GASES ON PORTLAND CEMENT CONCRETE.

By SIDNEY H. CHAMBERS

(Engineer and Surveyor to the Hampton Urban District Council).

Mr. William Dunn, F.R.I.B.A., Member of Council of the Institute, presided.

MR. SIDNEY H. CHAMBERS, Reader of the Paper.

THE subject of the present communication, the author stated, was one in regard to which it might be assumed that the available evidence was either inconclusive or of a more or less negative character. For, notwithstanding that cases were on record of destructive changes in tanks and sewers, the opinion tended to prevail that when the concrete construction was sound no marked disintegration need be anticipated, either from sewage or from its emanations.

The author's experience, however, did not support this view, and it was to the elaboration of this, the positive side of the question, that he desired to direct attention. During the last five or six years he had had very special opportunities for studying the problem.

In order to be in a position to more fully appreciate the disintegratory changes occurring at Hampton, and the deductions drawn from them, the author thought it was necessary to describe, even though briefly, the installation in question, and to state the character of the sewage, as well as to outline the nature of the materials used in the construction of the tank and channels.

The Hampton Installation. — The nature of the sewerage system was water carriage, primarily flowing by gravitation, and, secondarily, raised by plenum pneumatic power. The sewerage was entirely and completely on the separate system. The installation consisted of a screening chamber, two detritus tanks, a hydrolytic tank, and triple contact beds, and an air purifying filter.

The sewage on its arrival at the works was delivered from the rising main into the screening chamber, and, after passing through the screen, was conveyed by a channel to the detritus tanks. From these tanks the sewage entered the hydrolytic tank, which, together with the detritus tank, was installed in 1903. The disposition of the tank was such that the main bulk of the sewage—80 per cent.—passed through at a comparatively high rate of flow, issuing in four hours as a clarified liquid, whilst the small volume—20 per cent.—containing the deposited matters, was sixteen hours in the tank. After flowing over the weirs of the first portion the liquid entered a channel which led to the second portion of the tank, consisting of four hydrolysing chambers arranged in sequence, and filled with large flint stones. The liquid having taken three hours in its passage through these four chambers, entered the lower channel, which conducted it to the contact beds.

The screening chamber, the tank, and the channels leading to and from the tank, as also the effluent channel of the primary contact beds, were covered in. The entire installation was ventilated by the hydro-mechanical system of sewer ventilation, and the withdrawn gases were purified by being passed through an air filter.

The sewage of Hampton was of a strong domestic character. It had undergone thorough disintegration by the lifting operations, and by the putrefactive changes occurring in the rising main. It was malodorous on its arrival at the screening chamber, where, as it left the rising main, it evolved sulphuretted hydrogen and other bad smelling compounds. The liberation of these gases constituted a nuisance necessitating the screening chamber, channels, and tank being covered in, and a means being provided for drawing a large volume of air through them before discharging the gases into the atmosphere.

The Concrete Used.—The whole of the tank and channels, the author said, were constructed of Portland cement concrete. The walls of the tank are 6 ft. 6 in. in thickness at the base, and 1 ft. 6 in. at the top, and are strengthened by tie-rods; the roof was 6 in. in depth and was reinforced by "expanded metal," and the channels were covered by 2-in. "Indurated" paving slabs. The work was executed by departmental labour, and the best materials were used.

The concrete was composed of one part of Portland cement properly mixed with clean water and six parts of ballast thoroughly free from loam, clay, mud, or dirt of any kind, and no material was allowed to be larger than would pass through a 2-in. screen.

The makers of the "Indurated" paving flags state that they are composed of Mountsorrel granite chippings, washed and crushed to pass through a $\frac{1}{4}$-in. mesh sieve, and heavy Portland cement made by themselves, the raw material for which is obtained from the Barrow-on-Soar Blue Lias beds. The materials are mixed in the proportion of one part of cement to three parts of granite.

Efflorescence.—Early in 1905, a few months after the hydrolytic tank had been put into use, it was noticed that the roof and walls of the hydrolysing chambers above the liquid level were white or yellowish in appearance. This efflorescence was not crystalline in structure, but was of a chalky subsistence, and resembled distempered work on a damp wall. On examination it was found to be due to a thin covering of sulphur, which could be easily removed by rubbing. Later the face of the walls and the roof in the second part of the tank showed signs of peeling, and the concrete appeared to be disintegrating. A thorough inspection of the installation was thereupon made.

Disintegration.—At the screening chamber nothing appreciable was observed, neither at the highest water-level nor on the underside of the roof. The concrete was sound, and when struck had a good ring. Immediately adjoining this chamber was the main sewage inlet channel, along which the whole of the gases pass to the main air duct leading to the air filter. At this point slots were made in the concrete to receive a dam; the concrete at the back of the grooves was found to have disintegrated, although the sides were perfectly sound.

Further along this channel it was observed that the greatest disintegration had taken place on the walls at the liquid level. Owing to variations in the flow of the sewage, the level of the liquid in the tank and channels rose and fell; thus a certain area of the walls was constantly being immersed in the sewage and then exposed to the air. This area was, consequently, even when not immersed, much wetter than the part of the walls which was always above the level of the liquid. The latter area at this point showed erosion, which, however, had not penetrated so deeply as that at the level of the liquid itself. At the liquid level there was a deep groove in the concrete, and above this the face of the work had bulged out and lost its nature.

The first portion of the tank, *i.e.*, the hydrolytic tank proper, appeared to have suffered very little. The walls and roof had only the slight sulphur deposit. At the liquid level, which varied less than in the channel, there was a slight erosion. The second part of the tank, *i.e.*, the hydrolysing chambers, was found to have suffered in places to a marked degree. It was observed on breaking through the erosion on the surface that the concrete at the back was moist, soft, and gritty. Also, it was noticed that increased dampness constituted an important factor in the destruction of the concrete, for the lower parts of the vertical faces of the beams supporting the roof were more affected than the upper parts. The lower portions of the vertical walls of the tank also were more eroded than the upper. At the liquid level the concrete had been severely attacked, and a deep groove existed in it.

Analyses of Concrete in Hydrolytic Tank.—Two samples of surface concrete were taken above and below the liquid level, and the following was the result of the analyses :

	Below Liquid Level. Sound.	Above Liquid Level. Unsound.
Appearance	Grey	White
Texture	Hard	Soft
Ratio cement to sand	1 : 2	3 : 2
Sulphate of lime in cement	Trace	66 per cent.

Considerable Deterioration.—The same pronounced effect was to be seen in connection with the concrete blocks, which were grooved to receive sliding boards and project above the liquid level; these blocks had in many instances crumbled away to such an extent as to be almost shapeless. Recently these chambers were emptied, and it was found that the concrete below the liquid level was perfectly sound and in a good state of preservation.

The lower channel conveying the liquid from the tank to the contact beds revealed the same characteristics as were observed in the upper channel, but the portion at the liquid level was very much more markedly affected.

Analyses of the Disintegrated Concrete in the Channels.—Samples taken of the lining of the sides and covering gave the following analyses :

	Ratio.		Sulphate of Lime in
	Cement.	Sand.	Cement.
1. Concrete at varying liquid level	1	1	70·26 per cent.
2. Underside of slab forming covering ...	5	1	74·61 per cent.

The air duct taking the gases from the effluent channel of the primary beds and communicating with the tank outlet channel was found to have a coating similar in appearance to that observed on the underside of the covering to the channels.

Analyses of Concrete in Air Duct.—Analyses of this coating were made, with the following results :

	Ratio		Sulphate of Lime
	Cement.	Sand.	in Cement.
Underside of slab forming covering of air duct...	2	1	70·71

Conversion to Sulphate of Lime.—The point to observe in the above analyses was the conversion of the lime in the cement into sulphate of lime, the sulphur being obtained from the sewage flowing through the tank and channels, as well as from the gases expelled from the sewage, and contained in the air withdrawn from the several parts of the installation.

Suggested Explanation.—Much thought had been given to the explanation of the foregoing observations, and it had been concluded that the effects had arisen from the putridity of the sewage and the oxidation of the putrid products by the air supply. The main erosive effect was at the varying liquid level, and was there dependent upon the amount of sulphuretted hydrogen in solution in the liquid. The gas was comparatively small in amount in the incoming sewage and in the liquid in the hydrolytic tank, and increased as the liquid passed through the hydrolysing chambers. The results of this were especially well shown in the two channels; the alternate wet and dry area of the upper channel conveying the sewage from the rising main was less markedly affected, whilst in the lower channel the corresponding area was severely attacked.

So with the two parts of the tank; the first part into which the sewage was delivered, and wherein comparatively little putrefaction took place, had not been affected to anything like the extent that the second part or hydrolysing chambers had.

When the level of the liquid fell it left the concrete which it previously covered wetted with a liquid containing sulphuretted hydrogen in solution. This wet surface was then exposed to the action of the air supply, which oxidised the sulphuretted hydrogen with the production of sulphur and sulphuric acids; these decomposed the concrete, the lime being converted finally into sulphate of lime. What the exact nature of the intermediate compounds was could not be stated, as none of them had been isolated, but it was probable that the active agent was sulphurous acid, as it was known that cement was insoluble in sulphuric acid. When the liquid rose again, the decomposed concrete was washed away either wholly or in part, and a fresh surface was exposed to action when the liquid fell again. It was the continuation of this cycle which led to the formation of the grooves at the varying liquid level.

Concrete above the Liquid Level.—The erosive effects on the concrete above the liquid level were dependent upon the sulphuretted hydrogen evolved from the liquid and mixed with the air supply. Some of this gas was dissolved by the moisture which was present on the walls and roofs, from evaporation and condensation; it was then oxidised by the air, and decomposed the concrete as described above. In this case the decomposed concrete either remained as a coating on the surface, peeled off, or crumbled away.

Effect on Concrete Tubes.—In order to observe the phenomenon on concrete tubes, two 9-in. concrete tubes were selected, which were supplied by the makers of the paving slabs previously referred to, and were composed also of similar materials in the same proportion. One of the tubes was coated with Dr. Angus Smith's composition (coal-tar, pitch, linseed oil, and resin). They were placed side by side in the second part of the tank in such a position that they would be subjected to the rise and fall in the level of the liquid. At low level the tubes were not in contact with the liquid, and at high level the liquid rose to half the diameter.

After the tubes had remained in the tank for eight months they were taken out and examined. The coated tube did not appear to have been affected, other than at the highest liquid level, where a thin line could be observed, and when struck it was found hard and had a good sound. It was noticed that there were two areas on this tube without any coating, due no doubt to its having been placed upon two supports to allow it to dry; these areas were soft on the surface and similar to the uncoated tube. With these exceptions the tube appeared to be in as good a condition as when first placed in the tank. On the other hand, the uncoated tube had a distinct line at the highest liquid level, which was found to be soft, and when tapped with a chisel had a dull sound; the interior of the tube which had been immersed appeared soft and had a dull sound when struck; the portion of the tube above the liquid level was unaffected, and when struck had a clear ring.

The author then referred to other cases of disintegration of concrete by sulphur compounds.

Conclusions.—The deductions to be drawn from the investigations were that the gases in solution in sewage, and those expelled from it, arising from its decomposition, do act injuriously upon Portland cement concrete, notwithstanding the fact that the concrete is constituted of sound and good materials, when the following conditions prevail:

1. A high degree of putrescence of the sewage.
2. A moistened surface, which held or absorbed the putrid gases.
3. The presence of a free air supply.

Further, that in the absence of one or other of the above enumerated factors little danger from erosion need be feared.

Finally, the author accorded his obligations to Mr. T. Hughes, the manager of the Hampton Sewage Works, and to Mr. J. H. Johnston, the chemist, for their valuable assistance in obtaining the necessary material and data for the paper.

THE CHAIRMAN, MR. WILLIAM DUNN, F.R.I.B.A.

The Concrete Institute existed for the dissemination of knowledge on all matters pertaining to reinforced concrete, and Mr. Chambers to-night had done something towards making them acquainted with one of the dangers to which the work was exposed. It was not only in regard to waters which were highly charged with sulphur or sulphuretted hydrogen that dangers existed, because it had already been found that the water in the earth might act in such a way as to disintegrate both lime mortar, lime concrete, and cement concrete. Trouble of this kind had been experienced in several tunnels in France, with sewage pipes in Algiers, with sewage pipes in Texas, where the brickwork, in the one case, and the pipes in the other, were buried in ground containing alkaline waters. He was not sufficiently a chemist to offer any opinion upon the chemical changes which took place or the chemical conditions which made the matter dangerous.

There was a communication from ***Mr. Arthur Collins,*** the City Engineer of Norwich, who regretted exceedingly his inability to be present, and which he would now read :—

"City Engineer's Office, Norwich, April 20th, 1910.

"In reference to Mr. Chambers's paper on destruction of cement concrete in the 'Travis' tanks at Hampton, I have some concrete sewers under my care in Norwich which were laid in 1891, varying in interior diameter from 42 in. to 24 in., the total length of which amounts to several miles. They were brought into use for carrying sewage about 12 years since, and they show no signs whatsoever of deterioration. The main outfall discharges into a pair of concrete tanks forming screening chambers, and the concrete in these has not deteriorated. The sewage passing through these screens is pumped to the Sewage Farm, where for nearly 40 years it has been conveyed in an open concrete carrier, and in this there is no disintegration by chemical action. A few years since my attention was called to the brickwork of a reservoir built in East Anglia in which bricks from the Peterborough district were used. In this case the very high-class quality cement mortar was in parts quite disintegrated. I was informed this was due to the presence of sulphur in the bricks. A few years ago I was consulted respecting the failure of a retaining wall of a circular percolating filter constructed by the local authority of a town in East Anglia. The specification required the brickwork to be laid in cement mortar, but about 12 months after construction the wall collapsed. On examining it I found the mortar to have no appearance of being constructed with cement, it being similar in appearance and touch to that constructed from ordinary chalk lime when kept wet for a prolonged period; it was pasty and had no strength. I recommended that an analytical chemist be consulted, who reported the presence of a large quantity of sulphur. It appeared this sulphur came from the bricks, which were from the same district as those used in the reservoir referred to herein. Various experiences with disintegrated cement concrete work point to any excess of sulphur (whether in the cement or other materials used in constructing the concrete or introduced afterwards) as being very destructive of it."

Mr. H. K. G. Bamber, Assoc.Inst.C.E., F.C.S., writes as follows :—

"Portland House, Lloyds Avenue, London, E.C., April 21st, 1910.

"I very much regret that a previous engagement prevents my being present to-night to hear read and discussed the very interesting paper presented by Mr. Chambers. The paper is an extremely valuable one, as being a plain record of actual facts rather than an exposition of vague theories.

"The subject-matter of the paper is one that has on previous occasions come under my notice, and, in the main, I am in accord with the author as to the probable cause of the defects discovered in the concrete being due to the complex action of sulphur compounds, although there may be some doubt as to the precise action which takes place. I believe that a fairly warm temperature and moist atmosphere are necessary to produce the results stated by the author —i.e., the conversion of sulphuretted hydrogen into sulphuric acid.

"In this connection the author states that cement is insoluble in sulphuric acid, which is not quite in accord with the previous statement that the sulphuric acid decomposes the concrete. Cement in the form of calcium hydrate, in which it largely exists in concrete, is soluble in sulphuric acid, the suggestion that it is not, being simply due to the fact that during the action of sulphuric acid on the lime calcium sulphate is formed, which collects over the surface of the particles of calcium hydrate to be dissolved, and prevents the further contact with sulphuric acid.

"Calcium hydrate continually agitated with sulphuric acid is soluble in that reagent.

"It is possible that the reaction may be brought about also by the combination of the sulphuretted hydrogen with the lime of the concrete forming calcium sulphide, which is oxidised to calcium sulphate by the air passing through the culverts. In either case the result is a loose, friable material, which is washed away by the passing fluids, again exposing a fresh surface for such decomposition.

"The remedy seems to be in the formation of an absolutely impervious and smooth surface on the inside of the culverts, and in this connection my company are already engaged in experimental work with a special preparation of Portland cement to be used for this purpose. I am hopeful that in this way defects such as have been described by the author, and which may have been brought about by some special circumstances, may be entirely avoided. I recently had an opportunity of inspecting some of the main sewers in Paris lined with Portland cement which show no sign of deterioration, and I think the author's experience in this connection, for some reason, is somewhat unique, and must have resulted from some special circumstances, as such defects are not general in sewer work constructed in Portland cement concrete. In conclusion, I would thank the author for his valuable contribution to the list of subjects dealt with by the Institute."

The Chairman then called on Mr. Alfred Roechling to open the discussion.

MR. ALFRED ROECHLING.

Concrete was now very largely used in sewerage and sewage disposal works, and the engineer who had to deal with this class of work could not possibly do without that material, whether it be in simple construction or in reinforced concrete construction. Concrete was used for tubes, sewers, manholes, tanks—such as septic tanks, cesspits, tanks for the storage of night flow, and hydrolytic or Travis tanks—and the subject was of the utmost importance as regards the life of the concrete.

Concrete Tubes.—No alarm need be felt by anyone who had been using concrete tubes in consequence of the conclusions of the author, and if his remarks were correctly understood they limited the subject to one particular point—very foul or putrid sewage. The point was still further limited; the influence varied below the water level, and, further, the influence of very putrid sewage could only be felt when there was a large supply of free air. He thought wherever there was a chance of the formation of sulphurous acid concrete should be avoided. They had been using concrete tubes for 30 or 40 years, not only in this country, but also in America and on the Continent. On the Continent of Europe they had been used very largely, and some time ago a question was raised there as to what extent these concrete tubes could replace stoneware pipes. It was stated that the sewage had a very deteriorating effect upon the concrete. The investigations were very carefully made, and as a result of the various observations it was quite clearly proved that under ordinary conditions the sewage did not deleteriously affect the concrete tubes. There were, however, certain conditions under which concrete tubes ought not to be used, and those were exceptional or extraordinary conditions. For instance, where there were very hot liquids, say above 120° F., or where steam was discharged into a sewer, concrete should not be used for this reason—that through the various parts of the concrete tube, which were heated unequally, internal forces were set up which lead to a crack, and probably in many cases caused the collapse of the tube.

Concrete should not be used, at any rate, in immediate contact with the discharge of acids into a tube or sewer. In one case particularly which he remembered there was a discharge from some dyeworks opposite to the entry into the sewer on the other side of the wall, and the concrete of the sewer had been eaten away, the matrix had disappeared, and the pebbles were lying loosely on the bottom of the sewer. Then there was a case where the ground through which the sewer was laid contained a great number of pyrites, sulphide in some form, in consequence of which, by the formation of sulphurous acid, eventually the concrete tube collapsed. There was another case within his own knowledge of a reservoir for waterworks purposes constructed of concrete made with furnace lime. They would agree with him that that was a very improper material to use, especially as in many cases it contains sulphur. In 10 years the concrete collapsed; it got soft in places, and crumbled away in others. With the exception of these special cases, however, there was no need to fear that concrete tubes would be attacked by sewage or sewage gases.

He had examined septic tanks, and had also observed cesspits that had been in use for a number of years, where the cement was practically intact and very good. He would suggest to the author that the cause of that had been the absence of a great amount of free air. In Hampton they had artificial ventilation; they drew the air out, and it might be that in doing so the decomposition or the oxidation of the sulphuretted hydrogen proceeded more rapidly and more effectively.

MR. EDWIN AULT, M.I.Mech.E., F.S.I., M.R.San.I.

Some four years ago some samples of concrete pipes had been sent him for report upon the cause of corrosion. The pipes were made with good cement and clean, sharp sand, which on analysis of a new pipe showed a proportion of 1 to 1⅓ throughout. The pipes were 4 in. internal diameter, and had walls rather more than ¾ thick (0·77 in.). They were of the ordinary spigot and socket shape, and were of a length of 24 in. in the work. The quality of the pipes might be judged by the fact that under an internal hydraulic test they stood 100 lb. pressure per sq. in. when water began to oose out of the pores of the pipe. The pressure was then slowly increased to 120 lb. per sq. in., when the pipe failed by cracking at the spigot end.

The sample of neat cement used in the manufacture of the pipes gave, after 28 days, a tensile strength of 678¾ lb. per sq. in. Cement mixed with 3 parts of the sand used in making the pipes gave, after 28 days, a tensile strength of 360 lb. per sq. in. The fineness of the grinding of the cement gave only 3·2 per cent. residue on a sieve having 32,400 meshes per sq. in., and 0·6 per cent. on a sieve of 5,776 meshes per sq. in. The pipes were used for the conveyance of sewage, and the corrosion appeared only on the upper or aerial parts of the pipes, while the invert or lower parts of the pipe, which were covered with sewage, were found to be unaffected. Analysis of the white incrustation on the upper part of the pipe examined showed a large excess of sulphur anhydride (SO_3) in the form of calcium sulphate.

Curiously, an experiment with fumes of sulphuretted hydrogen directed on the pipe had no corrosive action. This was probably due to the absence of moisture. The portion exposed to the fumes turned black, which was attributed to the action of the ferric oxide contained in the cement. By suspending pieces of pipe in the fumes of sulphurous anhydride (SO_2) the calcium carbonate was changed into calcium sulphite ($CaSO_3$), which subsequently, on exposure to air, changed into calcium sulphate ($CaSO_4$). The pipes were in use in a tropical city, but our information did not show whether the cement pipes generally were affected or only those in certain districts. Bearing in mind the greater intensity of the decomposition of organic matter in the tropics and the great humidity of the ordinary atmosphere of this particular city, and also the fact that the sewage flowing through was a domestic one of great strength, and also bearing in mind the later experiences which Mr. Chambers had so lucidly set forth in his paper, he had not the slightest doubt that the corrosion of the pipes mentioned was due to the same causes as that which had been experienced at Hampton.

MR. D. B. BUTLER, F.C.S., Assoc.M.Inst.C.E.

About five or six years ago he had to examine a piece of concrete pipe, likewise in the tropics, which had been used about five or six years, and in this case, too, the conditions seemed exactly parallel to the case which the author of the paper had brought forward—that is, the concrete was corroded. The pipe was about 6 in. internal diameter and about 1 in. thick, and at the top of the pipe the thickness was reduced to ½ in. There was a coating of white deposit on the top of the pipe, which he likewise found to be largely sulphate of lime, and from analyses he made it was evidently due to the corrosion of the sulphuretted hydrogen from the sewage. Nearly all the alumina in the cement, this particular white deposit, disappeared; there were only practically silica, lime, and sulphuric acid. His explanation was that sulphate of alumina was formed, which the moisture from the sewage had caused to dissolve—it is a very soluble salt indeed—and it had run down the side of the pipe into the sewage again. He made some experiments at that time by treating some ordinary cement briquettes, composed of 4 of sand and 1 of cement, partly immersed in a solution of S_2S (sulphuretted hydrogen), and half in and half out of the water. The part of the briquette which was in the water did not seem to be affected, except to turn black, but the part which was in the gas was practically in four or five days disintegrated. A further experiment, by exposing briquettes entirely to the gas for two or three days, had a most peculiar effect. They swelled up to nearly 25 per cent. above their original size, and became quite rotten, showing very clearly that if cement is exposed to very strong H_2OS gas in a damp atmosphere it is disintegrated very readily. It seemed to him that if this pipe could have been better ventilated, so as to avoid the gases acting on the cement, this would not have happened.

One thing which rather struck him was the coarseness of the cement mentioned in Mr. Butler's paper. It was apparently only five years ago. If the residue on that sieve was as much as 27 up to 30 per cent. of the residue on a 50 sieve, and No. 3 sample is 2¾ per cent., that showed the enormous strides which had been made in the last few years as regards grinding cement.

MR. ARTHUR C. JAMES, Assoc.M.Inst.C.E.

Engineer and Surveyor to the Grays Urban District Council.

He had charge of some sewage works, where practically the whole of the tanks and other works in connection with the sewage treatment were formed of concrete. The districts through which the sewage flowed were very flat, and when it arrived at the works it was not only very strong, but was highly concentrated, and rather in a septic condition, giving off a good deal of sulphuretted hydrogen

The tanks into which the sewage flowed were formed of Thames ballast and cement, 4 to 1 concrete, and they have now been in use between 15 and 16 years. The concrete was absolutely as good as the day it was put down. There was no sign of deterioration whatever. After having been pumped from these tanks, the sewage flowed into some septic tanks, also of concrete, in which there was no sign of deterioration at all. It therefore seemed that there must be something in connection with the construction of the material of which the concrete was formed at Hampton which led to the action mentioned by Mr. Chambers.

MR. WILLIAM G. KIRKALDY, Assoc.M.Inst.C.E.

He knew trouble arose from any sulphur compound in the aggregate. Where breeze concrete had given way, it had been found to be attributable to the presence of sulphur.

He thought, perhaps, something might be considered on the question whether they could get the concrete as dense as possible. The more impervious they could get the concrete, the more mechanically dense, the better it would resist. He wondered, in the special circumstances that had been mentioned, whether it would be feasible to find any method of coating the concrete. One did not like to doctor concrete up with surface dressings, but it might be legitimate in certain cases. It would be very interesting if the chemists would follow that up.

MR. E. AULT.

With regard to imperviousness, he might mention that the Hampton tank stands about 14 or 15 ft. above ground, and there was no sign of leakage anywhere around the walls.

MR. E. P. WELLS, J.P.

He had hoped to see an analysis of the sewage in the paper. Mr. Chambers had told him that the sewage was purely domestic and exceptionally strong, and that no surface water whatever got into the sewage owing to the fact that everything had to be pumped. From his experience of sewers, where there was the greatest amount of sulphuretted hydrogen, especially in London sewers, was generally in the neighbourhood of cookshops, and that might be so at Hampton. The presence of sulphuretted hydrogen was due almost entirely to vegetable matter, and wherever a large amount of cabbage was used, or water from cabbages and vegetables of that kind, it was always highly charged with sulphuretted hydrogen, and as the sewage here seemed to rest for some considerable period before it was pumped up, this, of course, would cause further generation, and directly it came into contact with the concrete there would be a weak sulphuric acid, which acted very readily on the concrete, eating away the surface by the formation of sulphate of lime.

Now, in ordinary sewers, one invariably found that sewage increased the strength of concrete, and that there was no deterioration whatever ; in fact, where it was necessary to get a very quick setting concrete, especially in sewer work, where extensions or alterations were being made, it was generally the practice to mix a little sewage with the cement instead of using water. This caused a rapid setting and also hardening.

Another point that might be raised was as to whether the whole of the ballast used there was a good clean washed Thames ballast, or whether any bad ballast taken from the excavations round about Hampton was used, because if such was the case then he quite understood that the sulphur acted upon it very rapidly, because the whole of the ballast at Hampton was extremely dirty, and not fit to be used for concrete at all.

When they were over in Paris the other day they went to Achères to see a lot of tubes and pipes that were made by the Bonna Company. They had there for inspection a pipe about a metre in diameter. That was made 16 years ago. For 12 years it had been used as a rising main, and for four years it had been broken into and remained exposed to the air. As far as they could ascertain, both internally and externally, the concrete was practically as sound as the day it was made, and when the concrete was broken away and the steel exposed it was perfectly bright, in fact it was clean ; whereas when the steel had been put in it was all rusty. That showed that even with ordinary sewage, and the Paris sewage was also fairly strong, it had no effect whatever upon the concrete.

With regard to breeze, it was a well-known fact that the sulphur in it rapidly disintegrated the cement, and always caused expansion, and if added to that there was a lot of oxide of iron in the breeze, then the action became intensified.

MR. HERBERT E. BROOKS.

In the course of practical connection with cement work a great many of the difficulties which arose were due to carelessness ; in fact, sometimes a total neglect of ramming the concrete properly. When they got concrete that was not properly rammed, especially when it was 1 to 6, it would be absolutely full of voids ; and then, if there were any deleterious matter coming into contact with it, the destruction wrought was infinitely more rapid and more complete.

He had discussed many times with Mr. Nicol, the Harbour Engineer of Aberdeen, the well-known case of disintegration there, and he (Mr. Nicol) had often expressed the opinion that the main cause of the destruction which was wrought there in the historic case was the totally unsatisfactory way in which the concrete was put into place.

In a book which was recently issued by Professor Max Gary, the well-known chief of the Royal Testing Station for Building Materials, Gross-Lichterfelde, Berlin, who investigated the case of the destructive action of sewage and acids upon cement concrete pipes, an official record of the result of his investigation was given. On looking through that report he was surprised to find that there were a number of towns in Germany where the officials reported the existence of concrete pipe sewers 40 years of age, and in summarising the results of the reports officially obtained from the municipal authorities in charge of those places, practically the whole of the records showed that the destructive action of sewage upon Portland cement concrete pipes had been very few in number. The

Concrete Union of Germany, in discussing this very question, had laid great emphasis upon the necessity of a very careful ramming of the concrete work which came into contact with sewage, and he thought that the dangers which existed from the chemical actions which had been alluded to in this discussion would be very greatly minimised, if not altogether successfully resisted, by a very careful, complete, and thorough ramming of the concrete, and also if care were taken not to make the concrete too poor. As to filling the voids, one of the best, most successful and cheapest ways of filling the voids was with the cement itself, and it was a good deal better to have a rather richer mixture and prevent your deleterious fluids from penetrating into the fissures of the concrete at the outset than it was to have a dearer remedy afterwards.

THE CHAIRMAN.

They had had a most interesting paper and discussion. They had not united upon the remedy, but the cases of injury seemed comparatively rare, and they might take precautions against such injuries as did arise by a better class of concrete, and also by inquiring as to whether there ought to be discharges of hot water in the sewage pipes or a very strong domestic sewage going through them.

It was suggested that an increase of ventilation would be a benefit to them. He thought that in this particular case which had been described to them it was the presence of the air passing through it which made the thing not work. They knew, at any rate, that in cesspools, where there was very strong domestic sewage coming from houses, the cement lining did not perish, although the sewage was of the very strongest kind, because in most of those cases there was very little change of air; they have become, in fact, septic tanks.

He had great pleasure in putting to them a vote of thanks to the Speaker for the paper he had brought before them—(applause)—and would call upon Mr. Chambers to reply.

MR. CHAMBERS.

The Lecturer's Replies:—He wished to thank them very much for their vote of thanks, and also for the very kind way in which the members of the Institute and others had received the paper. He would prefer to communicate his replies in writing later on, but he would now take as many of the questions in hand as possible.

With regard to the temperature and other abstruse chemical elements, raised by Mr. Bamber, he would ask Mr. Johnston, their chemist, to answer them later.

Of course, in the main, he thought his conclusions answered many of the points raised by the different speakers. He had said that the gases in solution in sewage, and those expelled from it, arising from its decomposition, did act injuriously upon Portland cement concrete, notwithstanding the fact that the concrete was constituted of sound and good materials, when the following conditions prevailed:—(1) high degree of putrescence of the sewage; (2) a moistened surface, which holds or absorbs the putrid gases; (3) the presence of a free air supply. Further, that in the absence of one or other of the above-enumerated factors little danger from erosion need be feared. Corroboration had been found in the remarks of a few of the speakers, notably Mr. Ault and Mr. Butler. Mr. Butler particularly described the erosion in a more forcible way than he (Mr. Chambers) did himself. He referred to it as a bulging out and a swelling. As a matter of fact, that was just what had happened.

With regard to the analyses and tests of the cement, he had said that for the cement supplied the specification was drawn before the British Standard Committee had drawn up their Standard Specification, and the tests were well within the specification.

He did not altogether agree with Mr. Wells with regard to the Hampton ballast. There were different kinds of ballast at Hampton, as well as different kinds of granite in any local district, but it certainly was very dirty. Precautions were taken against that, and only clean was selected, and also the precaution was taken not to use any ballast that was near the site. The concrete was also well rammed. He would like to mention that not only was there sulphate of lime formed on the concrete they made themselves, but the percentage of sulphate of lime was very high on the slabs made with the granite aggregate coming from Leicestershire, so it was not altogether the ballast or the material.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE BRIDGE AT COTTA-DRESDEN.

As a frontispiece to this issue we present an illustration of a reinforced concrete bridge which was erected on the Möller system of horizontal girder bridges, by Messrs. Rud-Wolle, of Leipzig.

The bridge serves as a foot bridge over the Weisseritz at Cotta-Dresden, and has a span of 85 ft.

Owing to the pressure on our space, we must defer giving detailed particulars of this work in this issue, but drawings and a technical description will appear in a later number.

WHARF AT DIVES, FRANCE.

A wharf is at present in course of erection for the Société d'Electro Métallurgie de Dives, Calvados, France, and we think a description of the novel method of making the piles and sheet piles combined will be of interest to our readers.

The work is being carried out according to the new methods of Messrs. Edmond Coignet and Ravier, of Paris.

A glance at the design and photographs of the pile in our illustrations will immediately show the method of construction, and also the advantages offered by this new arrangement, which has been patented in France and various other countries, and recently in England by Messrs. Edmond Coignet, Ltd.

The wharf consists of a frontage of about 190 ft. in length. The main piles are driven at a distance of approximately 7¼ ft. centre to centre.

These principal sheet piles, which measure 10 in. by 12 in. in section, are composed of reinforced concrete, built in the manner of a Coignet pile, with round bars and stirrups in combination with spiral winding. The length of the pile is approximately 26½ ft.

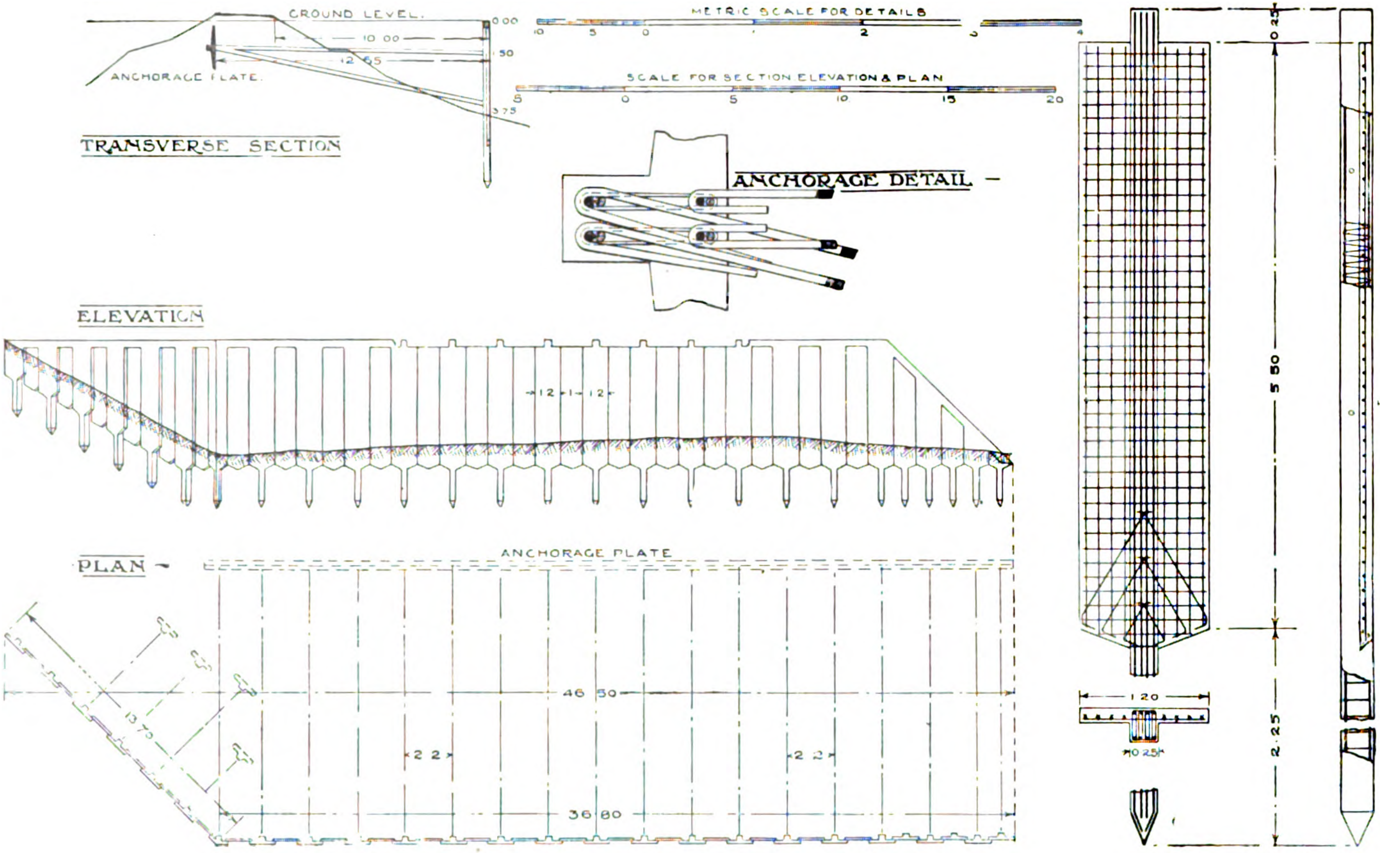
The panel or sheet pile, which is attached to the main body of the pile by means of a strong meshwork, measures approximately 18 ft. in height by 4 ft. in width, with a thickness of 5 in.

These piles, in combination with the sheet pile, are driven by a steam monkey in the same manner as an ordinary pile in reinforced concrete.

The main sheet piles are first driven, and the intermediate sheet piles, which are about 3 ft. 6 in. in width, are next driven with their edges resting on the inside of the principal piles, in order to form a complete retaining wall for the filling up, which is to be placed behind them.

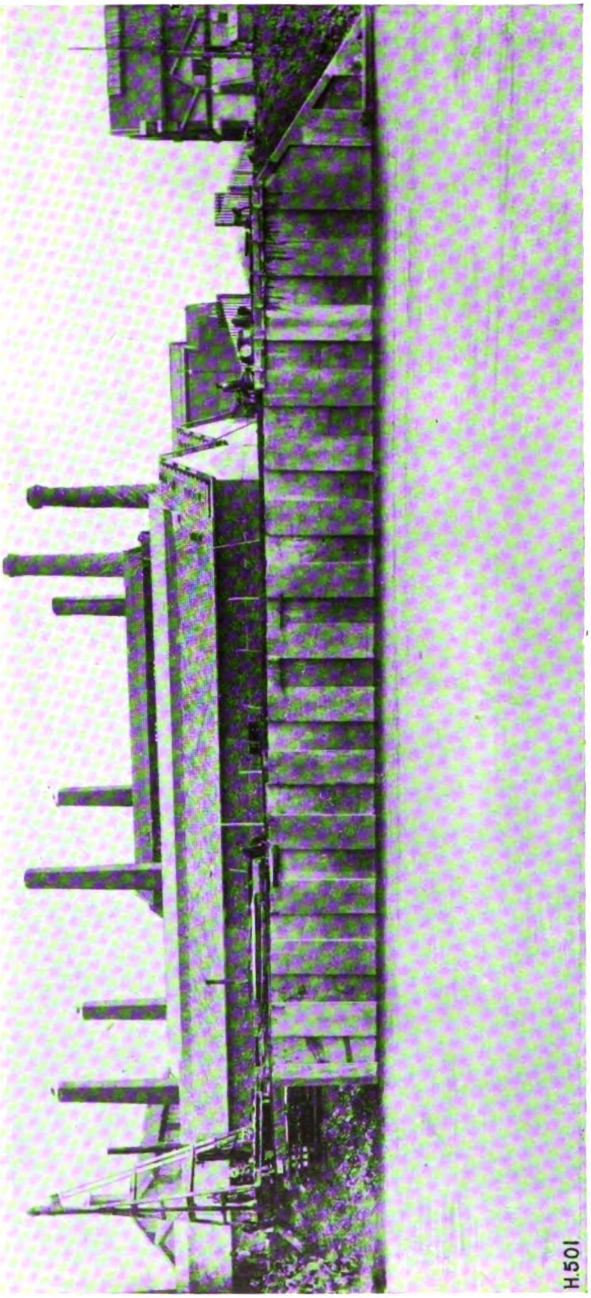
The main piles are maintained in position by land ties, fixed to a longitudinal reinforced concrete beam buried in the solid ground, in order to form a proper anchorage for the wharf front.

After all the piles have been driven in their proper position the heads are stripped



General plans and details of sheet piles on the Coignet system.
Wharf at Dives.

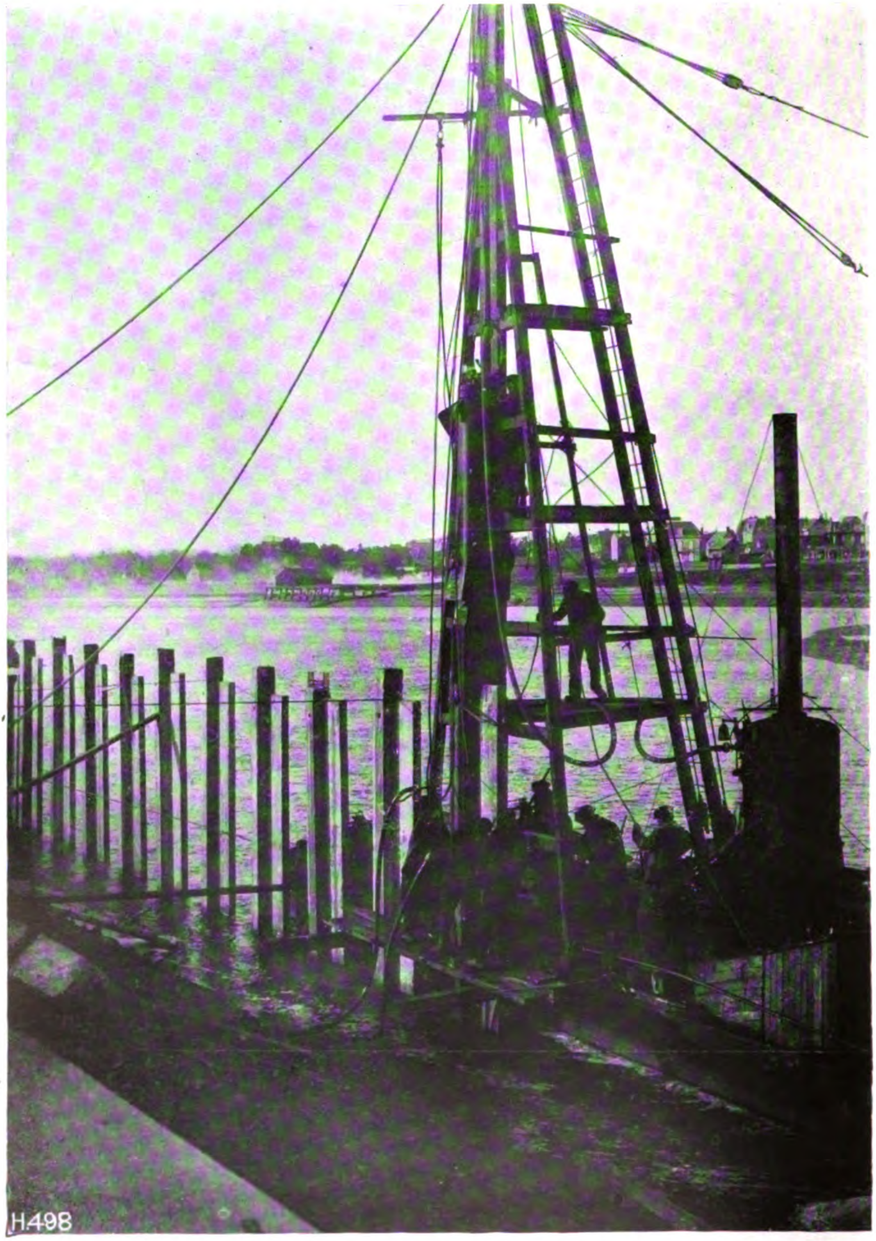
of their concrete and a longitudinal crowning beam is moulded upon these, so as to link them together, forming at the same time a coping for the top of the wharf.



Elevation of wharf almost completed, showing new Coignet sheet piles.

WHARF AT DIVES.

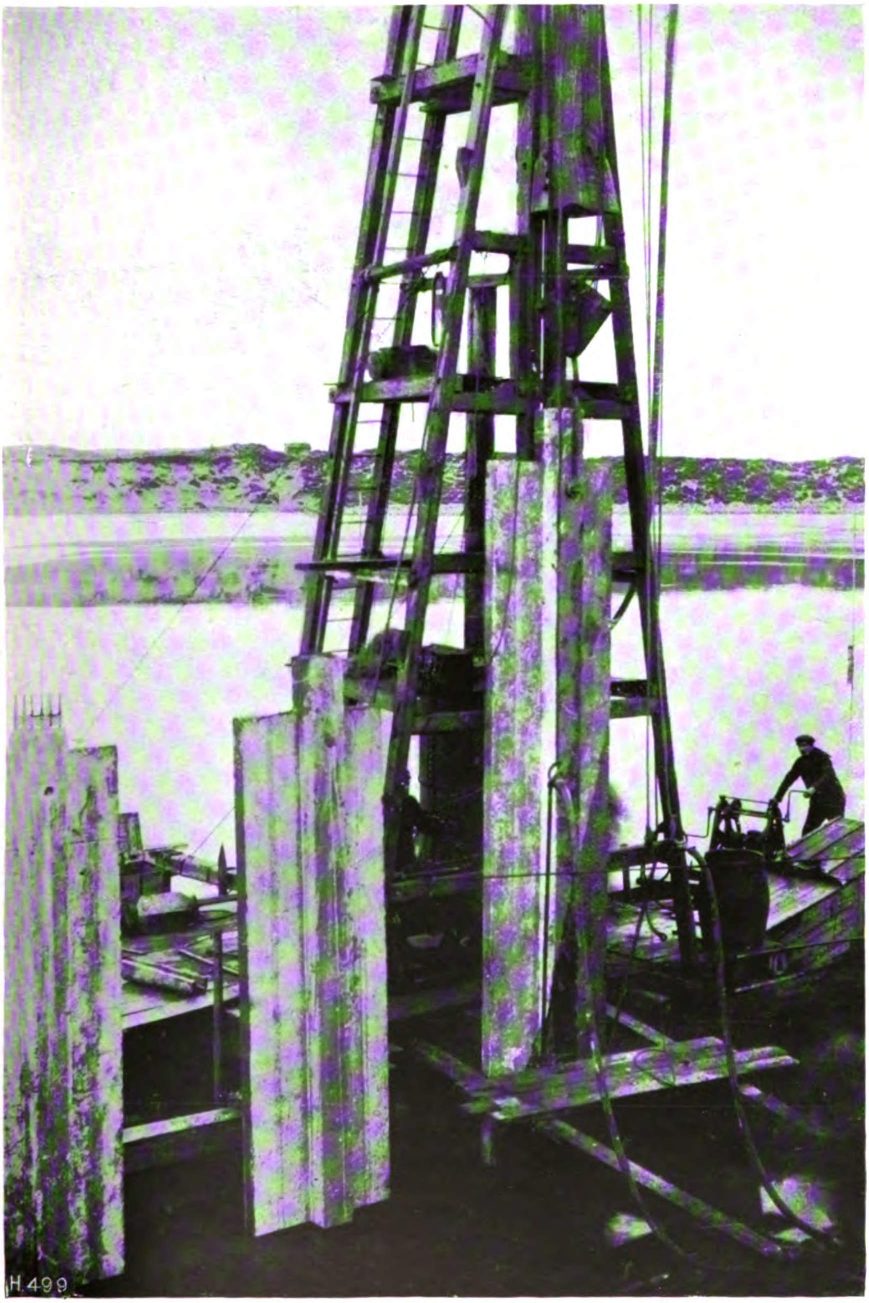
The inventor claims that these piles may be used to great advantage, not only for the formation of wharves, but also to divert the course of a river by placing a row of sheet piles across the current, in such a manner that the face of the sheet piles is diagonal to the current, so that the water striking the surface of the sheet piles is sent in a different direction to the original flow of the river.



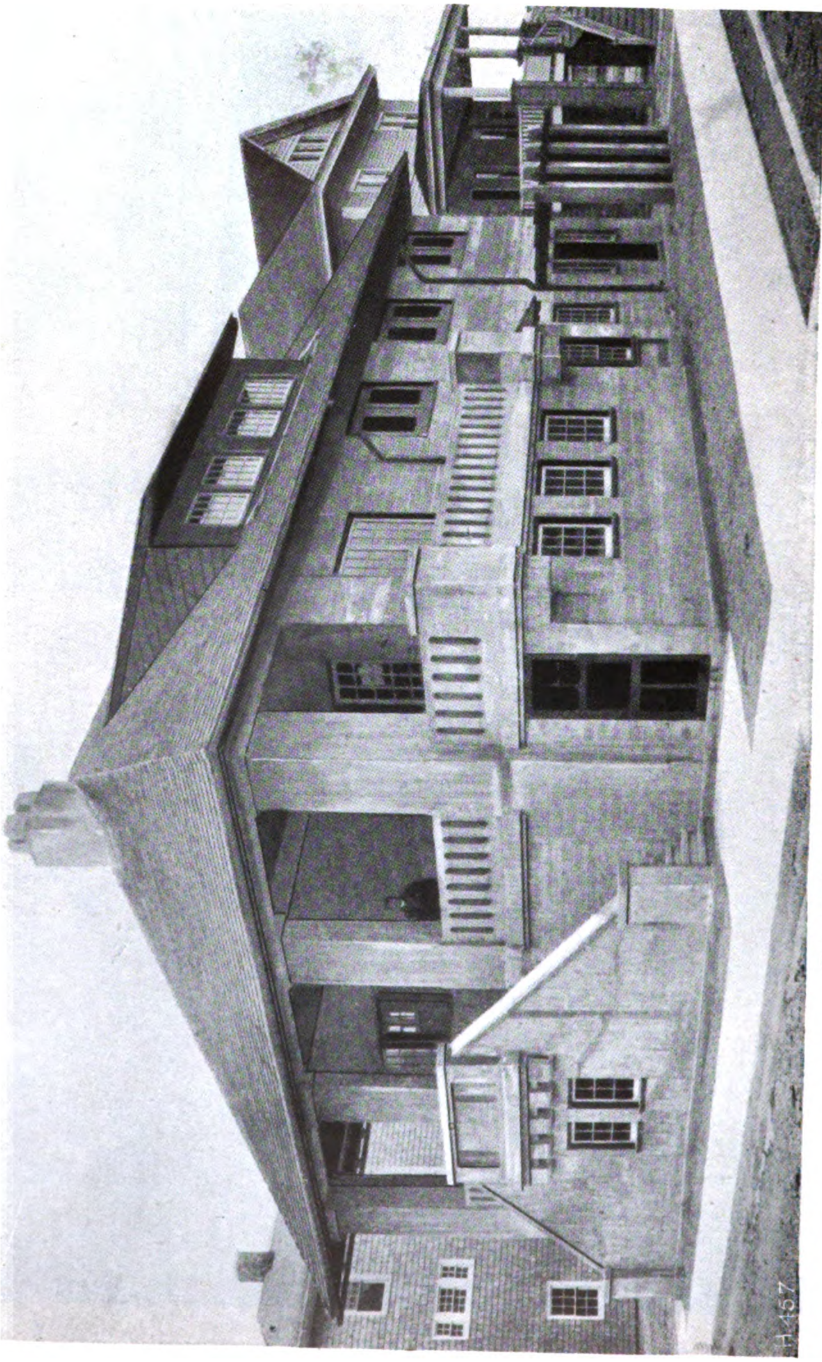
Bow of principal Coignet sheet pile in position.
WHARF AT DIVES.

CONCRETE HOUSE WITH UNTREATED SURFACE.

During the past few years there has been a great deal of discussion concerning the proper treatment of concrete surfaces, and the house which we are describing and shown on page 362 should therefore be of interest, on account of the entire absence of exterior treatment. This building certainly shows a very pleasing appearance, and it is difficult to see how any treatment could improve it. If a surface of this character



Driving a Coignet Sheet Pile.
WHARF AT DIVES.



Concrete House, with untreated Surface, at Ocean City, N.J.

is eventually accepted as appropriate there would be a considerable saving in time and money.

The dwelling is a double house, planned so as to preserve the outlines of a large single dwelling, and is thoroughly substantial throughout. It was erected at Ocean City, N.J., U.S.A., by Messrs. Carey and Reed, contractors, of Philadelphia. The house is 59 ft. by 36 ft. The requirements proved at first a very difficult problem for the architect. The house was for a small seaside town, which meant exposure to severe storms in winter and hot sun in summer. It was essential to have the greatest economy in space, and it was also necessary to keep the cost at a minimum, providing, however, for thorough workmanship and weatherproof qualities. After careful study concrete was chosen as the material best answering the various requirements.

Another feature of the house which should be noted from the view of economy is the fact that the walls are solid and only 6 in. thick. Confronted with a great amount of contradictory data on this subject, and so as to preclude possibility of moisture on the inside, it was finally decided to fur and plaster the inside walls with the exception of the walls supporting the porch. These walls are exposed to the weather, and have undergone a very severe test owing to the exposed ceiling, which is also the porch floor. During all the winter storms these walls, as well as the ceiling above them, have not shown the slightest trace of moisture upon the inside.

Regarding the concrete construction, the walls are carried on concrete footings 2 ft. wide and 12 in. deep. The footings are reinforced longitudinally and transversely with ½-inch square corrugated bars. At the top of the footing a recess was left to receive the wall. The outside forms for the wall were first erected and the window frames fastened in place. Then the inside forms were erected and the concrete poured. Forms were wired together at intervals of 5 ft. in both directions. The concrete was placed one story at a time, but the work was not continuous. When necessary to stop over night construction ceased at an angle so as to avoid a vertical showing joint.

The walls were reinforced with ½-in. square corrugated bars, spaced 12 in. apart vertically and 2 ft. horizontally. The vertical bars were left projecting 1 ft. above the first story in order that they might serve as an anchorage for the second story walls. The result is a perfect bond and an imperceptible joint. Thorough cleaning of the top of the concrete at the line of the first story was the only precaution taken to ensure a perfect bond, except, of course, careful spading. The entire ground floor of the house is a monolith joined to the footings. Floor sleepers were placed on top of this concrete sub-base and filled between with concrete of a thinner mixture and subsequently covered with the wooden floors.

The party wall is entirely concrete from the ground to the roof. The entrance porch is solid concrete, including the floor, steps and balustrade. It is 9 ft. wide and 8 ft. 6 in. above the sidewalk level, having a return at one side as shown in the picture. The porch is an integral part of the house and built at the same time. The front wall, in a sense, starts at the porch level, being carried on a reinforced concrete beam.

The massive concrete chimneys were cast with the house, and, like the porch, are an integral part of the house. Flue lining was placed upon the inside and the chimneys capped in red terra cotta.

The bath-rooms have white Portland cement floors with wainscoting of the same material all in trowel finish.

We are indebted to our contemporary, *The Cement Age*, for our illustration.

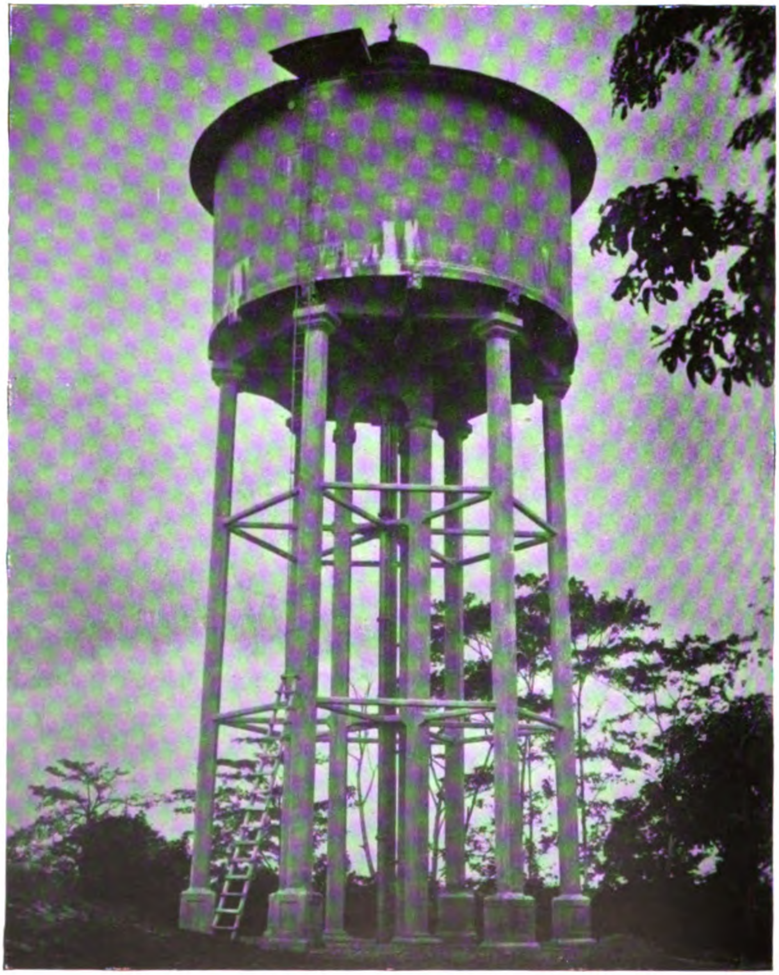
NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE WATER TOWER AT KUCHING (SARAWAK), BORNEO.

OUR photograph shows a reinforced concrete elevated water tank, constructed by Mr. H. F. Carew-Gibson, Commissioner of Works and Surveys, Singapore.



REINFORCED CONCRETE WATER TOWER AT KUCHING.

The tank is 16 ft. deep by 30 ft. diameter, internal measurements, and has a capacity of about 70,000 gallons. The foundations are 7 ft. below and the floor of the tank is 50 ft. 3 in. above ground level.

The nine legs, each 1 ft. 6 in. square in section, are reinforced with round steel bars wound spirally with mild steel wire, and are braced together twice in their height by means of 6 in. by 6 in. ties reinforced in a similar manner.

The floor of the tank is 8½ in. in thickness reinforced with 3 in. mesh expanded steel, carried by beams reinforced with round steel bars and expanded steel.

The wall of the tank is 7 in. in thickness, reinforced with 3 in. mesh expanded steel, square steel bars being also used at intervals.

The tank is lined with a 1 in. thickness of special waterproof cement plaster, laid on in two coats.

The roof, of the umbrella type, is of Billian (Iron Wood).

CONCRETE POTTERY AND GARDEN FURNITURE.

The illustrations which we present are taken from "Concrete Pottery and Garden Furniture," by Mr. Ralph C. Davison, Assistant Secretary to the Concrete Association of America.

The book is very tastefully got up, is well supplied with illustrations, and detailed instructions are given of how the different pieces are to be made.

The chapter dealing with coloured cements and the methods used for producing designs with them is particularly interesting, and the possibilities of ornamentation with concrete seem unlimited.

In the chapter on Garden Furniture there are a number of very effective sundials and vases, mounted on ornamental pedestals, any of which would greatly add to the picturesqueness of a garden. In *Fig.* 1 we show an artistic sundial made of concrete. If a sundial is to be placed on a pedestal it need not be cemented in place. They are usually made of brass or bronze and their weight is sufficient to hold them down. A good solid foundation must be prepared for the pedestal to rest on; and, in fact, all heavy garden furniture should be provided with good solid foundations, which should correspond to the size of the base of the piece which is to rest on them.

There are numerous designs of pedestals shown so as to give the reader some idea of the wide possibilities in design which can be obtained from concrete. The book also contains a number of illustrations and descriptions of artistic flower boxes, water jars, garden benches, balustrades and fences—all made of this material.

The book contains an elaborate description of how to make the glue moulds, or flexible moulds, which are extensively used in casting concrete ornaments in which the design embodies heavy relief work, such as in the highly ornamental table in *Fig.* 3.

The method of making cement pottery seems very simple. The first step is to make

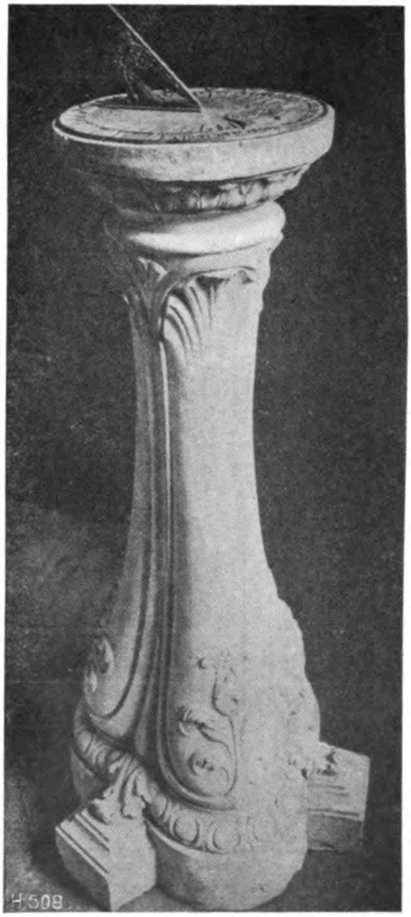


Fig. 1. Concrete Sundial.

the form to hold the Portland cement mortar, of which cement pottery is made, in shape. There are several methods of making these forms, but one of the simplest when

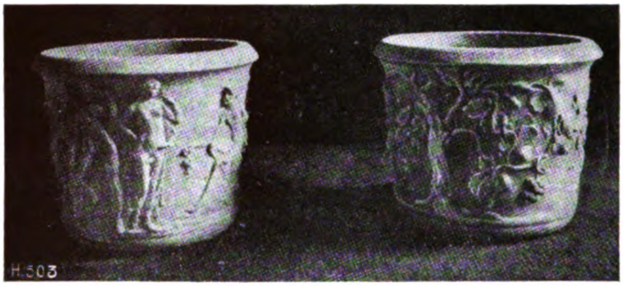


FIG. 2. CONCRETE FLOWER VASES.

only one article of the same shape is to be used is the use of wire frames. In a former issue we gave an illustration of these frames, one for a square and the other for a round piece of pottery.

Fig. 2 shows two flower vases made of concrete, and there are numerous other examples of this class of work.

This book should certainly prove of interest to both the professional and the amateur, and if the craftsman follows the directions given he will find it easy to produce satisfactory results.

We are indebted to the publishers, Messrs. Munn & Co., of New York, for the illustrations. The book is copyrighted in Great Britain.

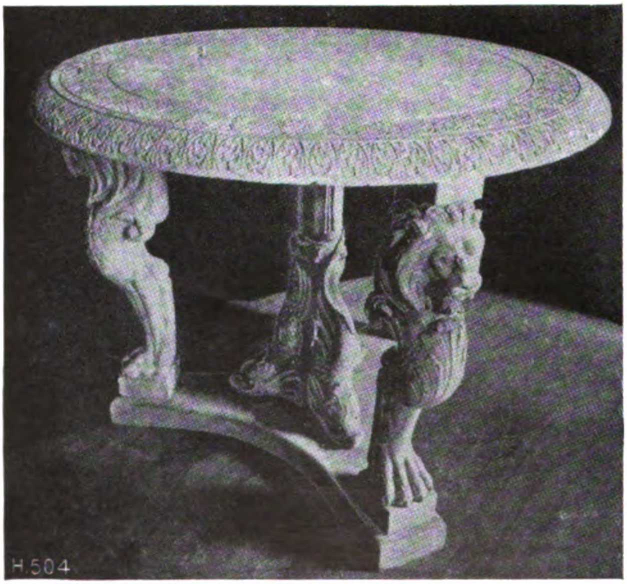


FIG. 3. ORNAMENTAL TABLE MADE OF CONCRETE.

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

CONCRETE MIXERS.

THE careful preparation of the mortar is the most important point to be considered in the manufacture of superior cement articles which will be able to stand competition in the market, as well as for reliable structures in concrete and reinforced concrete.

The more completely the different materials have been mixed the greater will be the economy in the consumption of the binding material. Most experts prefer to have the mixing done by machinery rather than by hand. The method of working the mixer, however, depends on the nature of the stuff to be mixed, and the construction of the machine must also be adapted to the daily output required. A continuous mixer can turn out considerably more in the course of a day than an intermittent mixer, but, on the other hand, the latter gives the advantage that the period of mixing can be considerably lengthened for materials which require it.

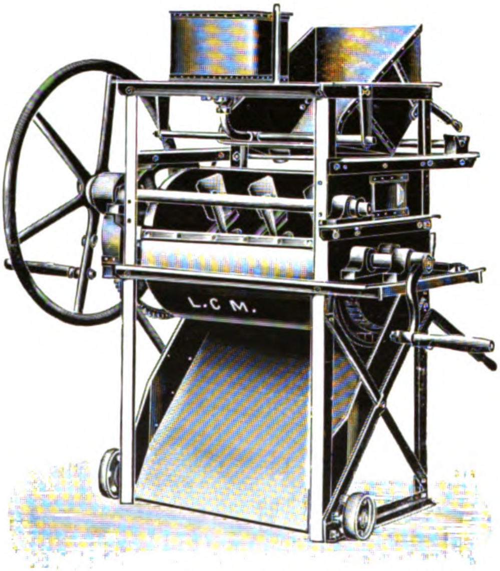


FIG 1. TILTING TROUGH MIXER. WORKED BY HAND.

A short description of the different machines manufactured by the firm Leipziger Cementindustrie Dr. Gaspary & Co., of Markranstädt, near Leipzig, should, therefore, prove of interest to our readers.

Intermittent mixers usually take the form of trough mixers, *i.e.*, machines which are provided with a trough, open at the top for the reception of the material; in the interior the mixing is effected by rigid or movable rotating mixing blades. These machines are fed in measured quantities, and, after having worked the material first in a dry and then in a wet state, the trough is emptied by tilting.

Fig. 1 shows a tilting trough mixer which can be worked by hand or power, and which is capable of mixing 2 to 4 cubic metres an hour, according to size. The materials are moistened through a perforated pipe, which is fed from a water supply box above the tilting trough.

There are two kinds of continuous mixers; first, those in which the material passes through without a stop, and in which the mixer must be fed in measured quantities. Secondly, those in which the materials are measured off automatically. The drum mixer, of which an illustration is shown in *Fig.* 2, belongs to the first type. Mixing shovels are provided in the interior of the rotating drum to ensure the thorough working through of the material; these shovels are turned by the rotation of the drum. By means of the supply tank above the mixing drum, and a perforated pipe, connected thereto, and extending into the interior of the drum, the mass, which was mixed dry in the first section, is moistened. The output of these mixers, which are built for

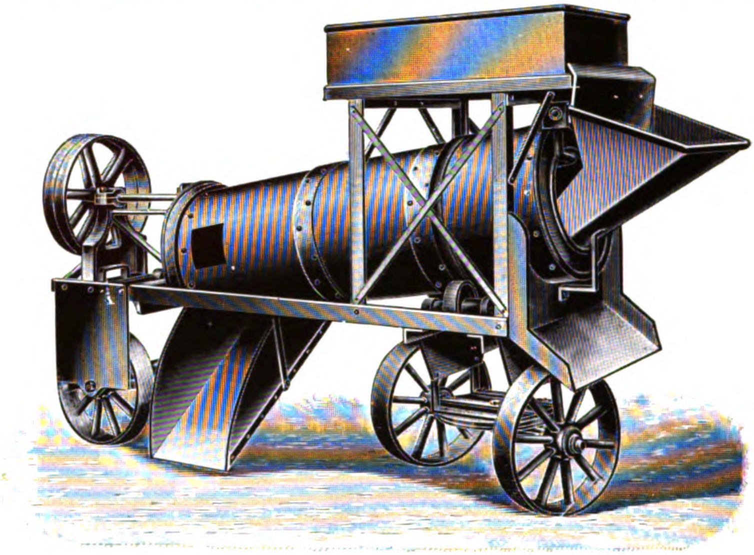


FIG. 2. DRUM MIXER. WORKED BY POWER.

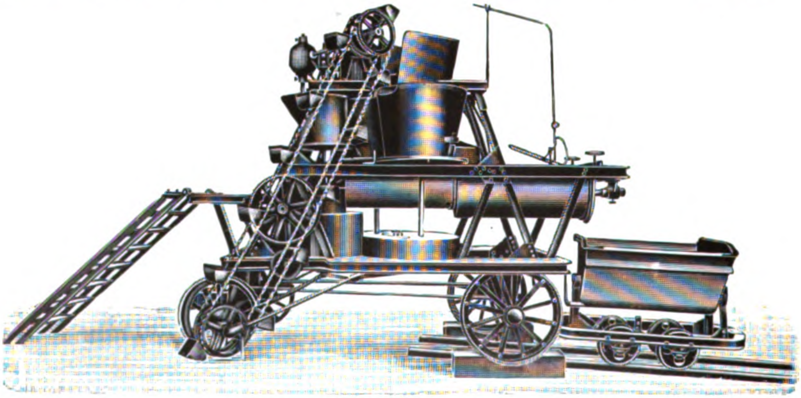


FIG. 3. FUNNEL-PLATE MIXER.

operation by hand or power, and which are either movable or stationary, varies from 3 to 5 cub. metres per hour.

The funnel-plate mixers, in *Fig.* 3, are continuous mixers which measure out the material automatically. The different materials are fed into funnel-shaped receivers which are open at the bottom, and below which there are rotating plates. By means of adjustable openings in the receiver the mass drops upon the projecting rims of the plates and is swept down into a mixing trough in which a mixing screw is working. The moistening of the mass is also effected in this trough.

All these mixers, after once being adjusted, measure the raw materials automatically; they are to be recommended where reliable help cannot be obtained. Such a machine worked by hand turns out from 1 to 1½ cub. metres per hour. When worked by power they mix from 2 to 20 cub. metres an hour.

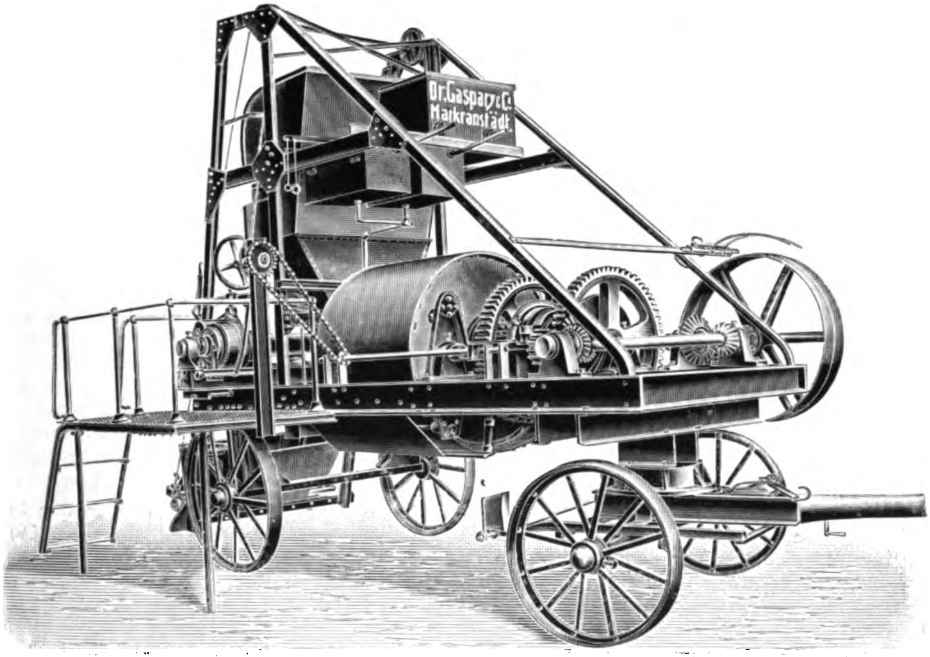


Fig. 4. Universal Drum Mixer. For Continuous Mixing.

The universal mixer shown in *Fig.* 4 is a continuous one, which combines the advantages of the best mixers heretofore known. It can also be made for intermittent mixing, with a trough open at the top as shown in *Fig.* 5. The mixing is done by means of mixing blades which rotate with the drum. The direction of this rotation can be changed by merely switching a lever, which is one of the chief advantages of this system. The repeated change of direction of the blades causes a more complete mixture of the materials, and by this means the mixer can also be more easily adapted to the existing motive power. It is easily seen that the power is considerably less when drums and mixing arms move in the same direction than when they go in opposite directions. The change in the direction of the rotation is also of great advantage for cleaning and emptying the mixing drum. Also by repeatedly changing the rotation any stones, etc., which may have stuck fast between the walls of the drum and the blades can be removed immediately.

It is absolutely necessary that mixing machines be adapted to the materials to be mixed, and they should be selected only after the output required and the power have been carefully considered.

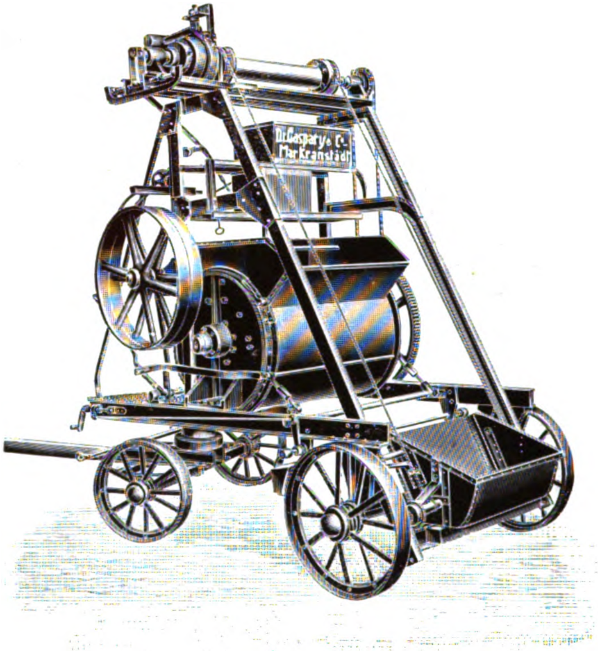


Fig. 5. Universal Drum Mixer. For Intermittent Mixing.

The Cementindustrie Dr. Gaspary & Co. are always pleased to allow anyone to inspect the mixers in operation at their own factory, or to give the names of firms in this country where the mixers are in use, so that prospective purchasers may get the best information possible and may see the general efficiency of these machines and how thoroughly the materials are mixed.

CORRESPONDENCE.

Under this heading we invite correspondence.

20 Victoria Street, London, S.W.,
April 18th, 1910.

Regulations for Reinforced Concrete.

SIR,—I have read with interest the article by Mr. William Dunn, F.R.I.B.A., which you have published in your April number concerning regulations for reinforced concrete buildings in London.

In your editorial notes on this article you evidently consider that Mr. Dunn is entirely against the adoption of regulations. I think, however, that this is not the case, but that he merely wishes to emphasise the danger of over-regulations, and, in this respect, I am entirely at one with him.

It is a matter of extreme importance to all specialist designers of reinforced concrete that there should be freedom to use it for walls and entire buildings in London and other large cities. Such regulations as are necessary should have a certain amount of elasticity. I think that in this respect the authorities would be well advised in copying the spirit of the French rules, which are drafted out in such a manner as to leave a considerable amount of scope to the skill of the designer, while at the same time safeguarding the public against any risks due to the fact that the concrete and the steel have been unduly stressed.

I am of opinion that the new regulations should state that the calculations of the resistance of the various members of the structure should be based upon the principles of the strength of materials, or upon principles affording at least the same guarantee of accuracy as those of the resistance of materials, and not upon empirical methods, which cannot be easily verified by the application of the usual well-known principles.

The fact that there are no *official* regulations at present is certainly very detrimental to the progress of reinforced concrete, in that the public hesitate to use it without such standard rules. In certain cases it is almost hopeless to try to reconcile the requirements of an economical scheme in reinforced concrete with the requirements of a district surveyor, who has officially nothing at present to guide him for the verification of a proper design.

As far as I have been able to ascertain, from conversations with the various firms of specialist designers, the recommendations set forth in the Report of the Committee on Reinforced Concrete of the Royal Institute of British Architects would seem to give satisfaction to everyone concerned, and I think that with a few amendments the authorities could quite well base their regulations upon this report; but it is essential that the rules should be capable of alteration, to keep pace with the advancement of invention and knowledge.

Yours faithfully,
EDMOND COIGNET, LTD.,
(G. C. Workman, *Managing Director*).

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

April, 1910.

London's Regulations for Reinforced Concrete.

SIR,—The article on "Regulations for Reinforced Concrete Buildings in London," which Mr. William Dunn, F.R.I.B.A., contributed to your columns last month, was of great interest. Mr. Dunn, however, raised controversial points, and though he put his case clearly and argued forcibly and pointedly as is his wont, it is unlikely that everyone will admit that he is altogether right.

Mr. Dunn's complaint against building regulations becoming specifications is a just one, and the writer agrees that American by-laws run to excess in that direction, but where buildings are erected close together in towns there must be some supervision in order to protect the public and to prevent the individual infringing upon the rights of others. Such a function can hardly be served by such a simple code of by-laws as that for which Mr. Dunn sighs. When architects and builders are all registered and educated in the mechanics of building, we may profitably discuss whether we can leave the individual without supervision by public authorities. The Joint Committee on Reinforced Concrete appointed by the Royal Institute of British Architects, in the drafting the reports of which Mr. Dunn has a large share, specially asked the authorities to make regulations for reinforced concrete construction, and Mr. Dunn, so far as the writer's knowledge goes, has never expressed himself at variance with the rest of his Committee on the point until the London County Council sought to act on the suggestion. He ought to praise the London County Council for moving so quickly after the report, and on securing the powers which the R.I.B.A.'s Committee desired it to secure. The paragraphs in the Committee's report referred to are as follows:

> "The By-laws regulating building in this country require external walls to be in brick, or stone, or concrete of certain specified thicknesses. In some places it is in the power of the local authorities to permit a reduced thickness of concrete when it is strengthened by metal; in other districts no such power has been retained. We are of opinion that all by-laws should be so altered as to expressly include reinforced concrete among the recognised forms of construction.
>
> "A section should be added to the by-laws declaring that when it is desired to erect buildings in reinforced concrete complete drawings, showing all details of construction and the sizes and positions of reinforcing bars, a specification of the materials to be used and proportions of the concrete, and the necessary calculations of strength based on the rules contained in this report, signed by the person or persons responsible for the design and execution of the work, shall be lodged with the local authority."

Now surely, if all these details are to be furnished the local authority should have some standard whereby to check them. And it should be noted that the R.I.B.A. Committee are evidently not in agreement with Mr. Dunn's opinion as expressed in his examination before the House of Commons Committee on the Bill promoted by the L.C.C., that the furnishing of details of the structural design would delay the erection of buildings in London and result in loss of income and increased expense, confusion and annoyance to building owners, to an entirely unnecessary degree.

It is generally admitted that the London Building Act of 1894 was cumbersome, often ineffective and unnecessarily oppressive, but this is chiefly attributable to its form, the regulations being fixed hard and fast by Act of Parliament, which had to be enforced, and could not be altered or amended without going to Parliament again. The later Acts have had saving clauses which give power to the London County Council to alter and amend regulations from time to time, but this, it has been thought, would give power to the officers of the London County Council, without subjecting them to supervision and power of appeal against possible arbitrary use of that power. The desired control is now secured by providing that regulations shall be submitted in draft to the technical societies and finally approved by the Local Government Board, and by having the Tribunal of Appeal to give a reasonable interpretation in case of dispute. Mr. Dunn sandwiches his argument with a number of trite remarks that will not be disputed, but they do not always apply. How such regulations as those recently adopted for steel-frame buildings can legitimately be said to remove the responsibility from the individual it is difficult to see. It is rather surprising to have Mr. Dunn advocating the policy of *laisser faire* in connection with regulations for reinforced concrete, for he is the consulting architect whom H.M. Office of Works gets to examine and advise upon designs submitted in competition by reinforced concrete specialist firms, and these designs have to be prepared in accordance with the report of the Joint Committee appointed by the Royal Institute of British Architects, which goes into considerable detail.

There is a great temptation in these times of keen competition for contractors to take risks and reduce factors of safety. Though no serious accidents have fortunately occurred in London, there have been some elsewhere, and, indeed, there have been failures in London which have given proof that supervision is highly desirable. Of course, it is admittedly impossible for public officers to keep a constant supervision over materials and workmanship; but it is just as well to see that the working drawings are correct, and surprise visits can be made to jobs to see that the arrangements are such as to conduce to work being properly carried out. The district surveyors of London do excellent work at present in other directions with just as many imaginative disadvantages as are put forward by Mr. Dunn.

The very fact of the establishment of regulations for reinforced concrete in London should give an impetus to the use of this system of construction throughout the country, for it will remove all the doubts that many persons possess, will give a feeling of security and fixity of purpose, and establish reinforced concrete firmly as a customary method of modern building construction.

The detailed points that Mr. Dunn raises to illustrate his remarks should be easily met now that the rules are to be open to the criticism of professional societies. There are various fundamental principles of applied mechanics and some general agreement among engineers as to reasonable factors of safety to provide on the ultimate strengths of materials, and these can be the subject of regulations. There is much that requires investigation in connection with reinforced concrete theory, and practice has not yet settled down; but it is not too much to ask that the use of it in the construction of large buildings shall proceed with caution and the design be prepared with due regard to the laws of mechanics and to the stresses on the materials not being unduly high.

Yours faithfully,
CIVIL ENGINEER.

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

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5 Victoria Street, S.W.,
April 25th, 1910.

Tests on Columns.

SIR,—In the last issue of your periodical you gave an account of some tests on spirally armoured columns made under the direction of Mr. Wm. Dunn, F.R.I.B.A. As this account might, as published, have a prejudicial effect on the Considère system of spiral armouring, of which we control the English patent rights, we shall be glad if you will print this letter with a view to counteracting this possibility.

The first and full reports of these tests, which were made seven years ago, appeared in the journal of the R.I.B.A. for November 21st, 1903, and November 23rd, 1904. An account of them is also given in Messrs. Marsh and Dunn's work, "Reinforced Concrete" (Constable & Co., 1906), page 287, and your article is a partial but verbatim abstract from this volume.

In the full reports of his experiments in the R.I.B.A. Journal Mr. Dunn makes it quite clear that these tests were made with the special object of testing the effect of unskilled workmanship in conjunction with the Considère Spiral. The following quotation will show this conclusively:

> "This column (A) was made, by the writer's desire, by men having no special experience in armoured concrete work and under no specially skilled supervision; in fact, under such conditions as would apply to work *not* done by a concrete specialist."

The armouring was also purposely kept very light—the amount of the longitudinals being slightly less than $\frac{1}{200}$th of the volume of the concrete, which is the minimum recommended by M. Considère—in order that it might be clearly seen to what extent the spiral would assist in strengthening the concrete, and Mr. Dunn states that had the amount of spiral armouring been greater the breaking stress would undoubtedly have been higher. Even with the exceptionally light armouring of Column A—$\frac{1}{8}$-in. spirals and $\frac{1}{4}$-in. longitudinals—the breaking stress was raised from 84 tons for the plain concrete to 180·9 tons for the spiralled column. These facts are omitted in the account which you have abstracted, but are given in the reports in the R.P.B.A. journal, in which Mr. Dunn's final conclusions are decidedly in favour of spiral reinforcement.

The tests in question were made six or seven years ago, and it is regrettable that your contributor should not have given the source and date of his information.

Though the spiral armouring of M. Considère is now officially recognised in both France and Austria, on the result of their own impartial experiments, and may therefore be considered as definitely established, the stress of competition will not permit us to allow any misconception to pass without comment.

The Considère Construction Company.
(signed) T. B. SHORE, Manager.

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

[Our article was merely a plain statement of facts. It stated that "the columns were made by men having no special experience in reinforced concrete construction, and under no specially skilled supervision." We are glad to record the further data given in the above letter.—ED. C. *and C.E.*]

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Concrete Institute—Visit to Paris.—On Friday, April 8th, the deputation visited the Church of St. Jean de Montmartre, an extremely interesting structure erected in 1896 on the Cottancia system. It is particularly noticeable for the lightness of the construction, every endeavour having been made, seemingly, to reduce the dead weight of the building, and yet provide ample strength. Then a visit was paid to the Canal St. Martin to inspect the reinforced concrete roofing over a portion of the same. This work, begun at the end of 1906 and completed in fifteen months, consists of a continuous three-hinged arched covering on the Boussiron system, filled on top with earth which is laid out as a public garden with trees and makes it into a magnificent boulevard. The novelty in the construction of this arch is that the hinges are not independent articulations, but merely consist of reductions of the section of the arch, at which points bars are embedded sufficient in area to take the thrust, and simply covered with concrete to protect them against corrosion but in no wise to augment their resistance to compression. In the afternoon the deputation visited a reinforced concrete tank at Gennevilliers, an underground gallery at Argenteuil, and a culvert at Achères, in which were large pressure pipes, on the Bonna system, conveying sewage, that have been in use for sixteen years, all connected with the sewerage and sewage disposal works of Paris.

On Saturday M. Hennebique's house, No. 1 Rue Danton, Paris, and his country house at Bourg la Reine were visited. The first is a tall building containing a flat for M. Hennebique's personal use and offices used by staff of the Hennebique firm. The country house is a remarkable structure of reinforced concrete, which shows some of the possibilities of the system of construction. On the same day an elevated water tank, built in 1899 at Billancourt, and bridges, tunnels, cantilevers, platforms, and buildings in reinforced concrete on the Paris to Auteuil Railway were inspected. These were all on the Hennebique system.

Concrete in Mining Construction.—Recent mine disasters have directed attention to the desirability of using fireproof material in mining construction, and in a few instances some interesting and satisfactory pieces of work have been done with concrete.

Perhaps the most unusual of these was in the construction of the Kidder shaft of the Cleveland Cliffs Iron Company, near Princeton, Michigan. The problem was to reach a ledge lying about 100 ft. below the surface, of which the covering consisted principally of quicksand so thoroughly saturated with water as to make ordinary shaft-sinking impossible. It was determined to follow what may be called tunnel methods. A reinforced concrete shaft was erected on the surface to a height of 15 ft., and excavation was begun from the interior with a clamshell dredge operating through several sections of steel dredging cylinder sunk in the centre of the shaft. As the material was removed the shaft followed the course of the excavation by its own weight, moving along like a tunnel shield but under natural power. As the shaft settled it was built upon at the top and the building kept pace with the sinking until a depth of 87 ft. was reached, when a stratum of hard clay was encountered which could not be handled with the dredge. From this point the dredging shaft with slight alterations was equipped for compressed air operation, and the excavation continued by caissons to the necessary depth of 113 ft. The shaft is 16 ft. in diameter inside, and at the joint with the ledge the walls are 3 ft. 6 in. in thickness, gradually increasing from 2 ft. in thickness at the upper end.

Near California, Pa., the Monongahela River Consolidated Coal and Coke Company has made extensive improvements in lining the shafts of a mine throughout with concrete. A part of the work is a double-track section of the shaft 15 ft. wide in the clear and 8 ft. in height to the centre of the arch. The two shafts, which have a combined length of 425 ft., are lined throughout with concrete varying from 1 ft. to 2 ft. in thickness.

The H. C. Frick Coal and Coke Company, Pittsburg, has built two concrete shafts, one for working and the other for ventilation, at one of its mines in Pennsylvania. Both are elliptical in shape, one being 13 ft. by 28 ft., and the other 14 ft. by 34 ft. One shaft was begun by excavation by drill and blast to a depth of 50 ft., the dimensions being located by the use of a template with plumb bobs suspended from it. The excavation was kept 12 in. outside the lines of the finished shaft. At this depth collapsible forms were built and the concrete work completed to the full depth. While this work was in progress the excavation of the other shaft was completed and the concrete placed. The working force then returned to the first shaft and the two were carried on simultaneously to a depth of 650 ft. The excavation was nearly all through solid rock with the exception of about 18 ft. at the surface. The coping of each shaft for this distance through the surface soil was made about 5 ft. thick, and serves as a foundation for the pumping and hoisting machinery, while in the rest of the shaft the thickness varies from 12 in. to 24 in., the latter thickness being required in some of the softer strata of fire-clay and other materials. Though the cost of concrete construction was considerably higher than wood construction would have been, the size of the coal vein was supposed to be such as to warrant the extra expense, the view being that it would be counterbalanced in a period of years by lower maintenance charges.—*The Times Engineering Supplement.*

Tests of Portland Cement.—Dr. W. Burchartz reports the results of tests of 100 German Portland cements and of 20 Belgian natural cements, carried out in the Testing Station at Gross-Lichterfeld during the past year. The quality is found to vary within comparatively narrow limits, as is shown by a number of frequency curves included in the report. The average results of the Portland cements are: Apparent density 1·10—1·15; specific gravity 3·05—3·15; loss on ignition under 4 per cent. Residue on 900 sieve (British 76) 0—1 per cent., on 5,000 sieve (British 180) 15—20 per cent. The tensile tests on mortar after 28 days gave very closely 25 kilog. per sq. cm., and the compressive tests 200—250 kilog. per sq. cm. (356 and 2,820—3,560 lb. per sq. in. respectively). Practically all the samples withstood the boiling test.

On the other hand, the Belgian natural cements have a lower specific gravity (2·9—3·0) and commonly fail in the boiling test, although showing no unsoundness in a cold water test. The tensile and compressive tests are always lower, being usually 16—19 kilog. per sq. cm. and 116—160 kilog. per sq. cm. respectively for 28-day mortar (228—270 and 1,650—2,280 lb. per sq. in). They are ground to the same fineness as the Portland cements.

The chemical analyses show that the proportion of lime in German Portland cements averages 62·99 per cent., the maximum observed being 68·12 and the minimum 56·88. The average proportion of silica is 20·87, and of alumina and ferric oxide 10·61 per cent.

Gravel v. Limestone in Concrete Aggregate.—Comparing the relative value of washed gravel and crushed limestone as a factor in concrete aggregate, Mr. Arthur B. Hewson presented some interesting figures and facts before a recent meeting of the Architects' Business Association of Chicago. He contended that any given quantities of cement, sand, and gravel mixed in the usual proportions, such as 1 : 2 : 4 or 1 : 3 : 6, will make at least 7½ per cent. more concrete than equal quantities of cement, sand, and limestone; also that, at prevailing prices for gravel and stone, the former is decidedly the more economical, at the same time showing greater strength, efficiency, and fire-resistance. The explanation of the greater bulk of gravel concrete, said Mr. Hewson, is that gravel, on account of the rounded shape of its particles, averages 7½ per cent. less in voids than crushed stone. When you mix concrete 1 : 2 : 4 or 1 : 3 : 6

you have 50 per cent. of sand to fill the voids in the coarse aggregate. If the voids in crushed stone absorb 95 per cent. of the sand and the voids in the gravel only 80 per cent., it naturally follows that 15 per cent. more of the sand appears in the gravel concrete, thereby increasing its bulk 7½ per cent. Practically all authorities agree that the voids in the averaged washed gravel are 40 per cent. and in the average crushed stone 47·4 per cent. Continuing, Mr. Hewson said: It is agreed that the strongest concrete is that in which there is just sufficient sand to fill the voids in the coarse aggregate plus a small percentage to cover inequality in mixing, with the same conditions obtaining between the sand and cement. When you add more sand than this you weaken your concrete. Does it not follow that, if gravel concrete excels limestone when compared in identical proportions, it would still further excel in comparisons where the sand is in the same proportion to the voids in both materials? For illustration, would not a 1½ : 3 : 7 gravel concrete excel a 1 : 2 : 4 limestone concrete? Would it not be proportionately rich in cement? Would it not give an equal bulk of concrete and a greater strength efficiency with less sand and less cement? Furthermore, if a 1 : 2 : 4 limestone mixture produces a smooth finish, will not a 1½ : 3 : 7 gravel concrete do the same, since the proportion of mortar to the voids is identical in both cases? In confined spaces, where the intervals between the reinforcing bars are small or the concrete must be forced through wire mesh, a denser and, therefore, stronger concrete can be obtained with gravel. The rounded particles work into place more readily and lie snug to the steel. There are few jagged edges to catch on the steel or on companion particles, forming pockets which reduce the strength and damage the appearance of the surfaces. Gravel concrete, properly proportioned, will produce water-tight walls, where limestone will fail under the same conditions. This is also due to the lesser proportion of voids and the closer association of the particles. With regard to the fire resistance of gravel concrete, Bulletin No. 370 of the U.S. Geological Survey shows its superiority over limestone. The limestone is badly damaged by calcination. This bulletin also shows that fireproofing tile, sand-lime brick, and practically every other material except solid concrete, are useless for fireproofing.

Reinforced Concrete Paving Joints.—Among the first concrete pavements laid in the United States, according to the *Surveyor*, were those put down at Bellefontaine, Ohio, about seventeen years ago, and after such a length of service they are still in good condition, except for wear at the joints. Other similar well-constructed pavements in different cities show the same weakness. To overcome it Mr. R. D. Baker, of Detroit, Michigan, last year originated and used an "armoured expansion joint." The reinforcement consists of a steel plate at the edge of expansion joints wherever necessary to provide for expansion and contraction. Where such a joint is to be made each edge is protected first by a steel plate $\frac{3}{16}$ in. wide. Between the two edges thus protected is placed a board. When the board is removed the cavity left by its removal is filled in with proper paving pitch or other suitable material. Some of the pavements thus constructed in Detroit have been subject to severe tests in the way of heavy traffic, and, it is stated, seem perfectly satisfactory. The added cost is said to be little compared to the lasting improvement in wear.

Urban District of Wood Green.—Erection of Public Baths.—The Council invite schemes and tenders for a reinforced concrete swimming tank, heating of the bath, private baths, etc., and steel roof trusses and sliding lantern over same, from firms who are respectively specialists in such work.

Forms of tender, preliminary specifications, and copies of plans may be obtained at my office on or after 22nd instant, on payment of a cash deposit of £3 for each set, which will be returned on receipt of a *bonâ-fide* tender and drawing.

The general conditions, subject to which the contracts will be submitted, and all further information may (on the production of my receipt for the deposit) be inspected and obtained from the Architect, Mr. Harold Burgess, Capel House, 62 New Broad Street, E.C., between the hours of 3 and 5 p.m.

Sealed tenders (upon the forms supplied only) addressed to me, and enclosed in the endorsed envelope supplied, must be delivered to me at my office not later than 4 p.m. on Wednesday, May 11th.

The contractor will be required to pay the wages and observe the hours of labour in accordance with the scheme, a copy of which will be annexed to the contract. By order of the Council, Wm. P. Harding, Clerk of the Council, Town Hall, Wood Green, April 14th, 1910.

The "Licentiate R.I.B.A." — The Royal Institute of British Architects have issued the following letter to the Presidents of the Allied Societies on the subject of the new "Licentiate" class which, under the new Charter, is to be formed in connection with the Institute. The letter is as follows:

> DEAR SIR,—We have the honour to invite the attention of your Society to an important development in the constitution of the Royal Institute of British Architects which has lately been sanctioned by the grant of a Supplemental Charter and new by-laws by His Majesty the King and the Privy Council.
>
> A new class of members, having the chartered right to the designation of Licentiates of the R.I.B.A., has been created. This class is open to all practising architects of good standing who have attained the age of 30 years and either (*a*) have been engaged as principals for at least five successive years in the practice of architecture, or (*b*) have been engaged for at least ten successive years in the practice or the study of architecture.
>
> Candidates for this class are not required to pass an examination or to submit to election by the general body, but must satisfy the Council of the Royal Institute that they are fit and proper persons to be admitted to this class.
>
> *Under the provisions of the Supplementary Charter of 1908 candidates for the class of Licentiates will only be admitted during the twelve months from March 23rd, 1910, to March 23rd, 1911.*
>
> Under His Majesty's Charter any Licentiate who is eligible as a Fellow may at any time before December 31st, 1920, be admitted for nomination to the class of Fellows when he has passed an examination to be prescribed by the Council.
>
> Licentiates will be required to make an annual payment of one guinea to the Royal Institute, and for this they will be entitled (1) to use the affix Licentiate R.I.B.A., (2) to receive the *Journal*, the *Kalendar*, and other publications of the Royal Institute, (3) to use the Institute premises, and (4), subject to the Charter and by-laws, to attend the meetings of the Royal Institute.
>
> In view of the necessity of closer organisation of the members of the architectural profession throughout the Empire, both for the advancement of the art of architecture and for the promotion of the interests of the profession by means of Parliamentary or other action, it is highly desirable that a knowledge of this new means of becoming associated with the work of the Royal Institute should be spread as widely as possible among those architects who are at present outside its walls.
>
> Any action which may be taken in the future to secure a higher standard of professional attainment and a greater security for properly qualified architects can only be successful if it is based upon the support of a substantial majority of the practising architects of the Empire, and the Council of the Royal Institute hope that your Society will do all in its power to assist the efforts that are now being made to obtain this support.
>
> We have pleasure in sending you herewith a packet of nomination papers for Licentiates, and we shall be glad if you will take an early opportunity of making an official announcement and of taking effective steps by sending by post to all the architects in your province a notice of the creation of this class, drawing special attention to the fact that it is only open for twelve months, and informing them that the above papers are in your hands and may be obtained on application at the offices of your Society.
>
> We feel that it is the duty of the Institute and its allied Societies to get into touch with all architects in the Empire, and we are sure we may count on your zealous personal assistance to this end.

TRADE NOTICES, CATALOGUES, ETC.

The British Ceresit Waterproofing Co., Ltd., Caxton House, Westminster, have sent us an illustrated booklet setting forth the advantages of their preparation, which they claim is the most simple, efficient, and economical waterproofing on the market. Ceresit is a cream-white paste which dissolves immediately in the water with which cement mortar or concrete is to be mixed. A coating of cement mortar waterproofed with Ceresit has been found completely successful in rendering structures of any material, brick, stone, concrete or tile, thoroughly waterproof and damp-proof. Where new structures are to be built of concrete, they may be made waterproof throughout, without necessity for any extra coating, by using Ceresit in the water with which the concrete is mixed. No special mixing or expert help is required. Ceresit has been used by the State Government Railways of Germany, France, Russia and Austria; at

BLAW COLLAPSIBLE STEEL CENTERING

CHEAPER & BETTER THAN TIMBER & MORE EASILY HANDLED & BETTER FINISH ON THE CONCRETE.

FOR SEWERS, CULVERTS, CONDUITS, ARCHES, ROOFS ETC.

ILLUSTRATIONS SHOW CENTERS IN USE ON COMBINED BRICK AND CONCRETE CULVERT, FOR THE NORTH-EASTERN RAILWAY CO., AT BLYTH, NORTHUMBERLAND.

THE CONTRACTOR FOR THE WORK WAS MR. T. TELFORD GIBB.

THE BRITISH STEEL PILING COMPANY,

DOCK HOUSE,
BILLITER ST.
LONDON. E.C.

the Kaiser's Palace, Posen; Düsseldorf City Hospitals; Hotel Eden, Zurich; Sterrebeck Castle, Belgium; German Government dams, and reinforced concrete cisterns for the U.S. Government, Florida, etc., etc.

The British Fibro-Cement Syndicate, Norfolk House, Laurence Pountney Hill, E.C., call our attention to a report of a fire at Limon, Costa Rica, taken from the Costa Rican journal, *La Informacion,* in which it is stated that, in the centre of one of the blocks which were burnt down, one single house, although surrounded by flames on all sides, remained standing without having suffered any damage. This house, in the construction of which "Fibro-Cement" was used, is said to have "triumphantly emerged from a severe test, and proved to be an ideal building material at a port which is always threatened by fires."

The British Improved Construction Co., Ltd., 47 Victoria Street, S.W., gave last month, at their Fulham works, a most interesting demonstration of the Jagger system of construction in the manufacture of concrete sewer pipes, railway sleepers, telegraph poles, etc. A special feature of this system consists in the vibratory and oscillatory process to which the moulds attached to the Jagger table when being filled with concrete are subjected. This vibration, combined with a sudden arresting or rocking "cross" motion, has the effect of producing a rapid solidification of the particles *before* the initial set of the cement occurs. It is claimed that the greatest density and homogeneity is thus obtained, the aggregates being bound so closely together that air holes and cavities are entirely eliminated. The Company guarantee for all their concrete an absolutely uniform standard of strength, capable of calculation and variation in respect to the strength of the aggregates and the volume of cement used. With reference to the reinforced concrete sleepers made by the Jagger process, these are stated to be almost indestructible and everlasting, of a standardised strength and uniform finish, density and texture throughout, completely immune from hair cracks in the surface, and capable of construction at a very moderate cost. They have been used by the S. E. & C. Railway, and are also being tried by the Great Northern Railway.

Builders' and Contractors' Plant, Ltd., 17 Victoria Street, S.W. (whose former title was General Constructions Machinery Supply, Ltd.), have brought out a useful catalogue of their "Roll" concrete mixers, sand and gravel washers, etc. Numerous illustrations are given, together with descriptions and instructions as to methods of working both hand and power machines. Among the many important contracts on which the "Roll" mixers were used, the following may be mentioned :Antwerp Fortification Works, Brussels-Antwerp Canal, Amsterdam Harbour Works, Venice Fortification Works, etc.

The Trussed Concrete Steel Co., Ltd, Caxton House, Westminster, have brought out an illustrated pamphlet and price list respecting their "Hy-Rib" steel lathing for partitions, ceilings, walls, roofs, sewers, etc. Hy-Rib consists of a steel lath surface stiffened by rigid high ribs, and when used in concrete floors and walls no centering is required, the ribs giving sufficient strength and rigidity, while in walls and partitions it does away with the use of studs. The lath surface is straight and true, and the expansion is such as to produce a perfect clinch with a minimum amount of plaster. Hy-Rib is used in construction work of every kind, floors, roofs, walls, partitions, ceilings, and furring. Curved Hy-Rib (bent by the special rolls with which the firm's shops are equipped) is used for arched floors, culverts, conduits, sewers, silos, tanks and reservoirs. The booklet illustrates and indicates the general applications of the material, but detailed suggestions for any particular work will be furnished by the Company.

The Leeds Oil & Grease Co., of Chadwick Street, Leeds, have sent us some particulars of their Concrete Mould Oil, which should be of general interest. This preparation is, we understand, found to prevent the concrete sticking to the moulds in shuttering concrete, and also to protect the timber from the action of the wet concrete, thus lessening the possibility of its becoming warped or twisted, as might otherwise be the case. The oil is applied to the mould or shutter with a brush, and should, if possible, be allowed to dry somewhat before the concrete is filled in. Special mention is made ot the low price of this Concrete Mould Oil, as also of the fact that it has been used by the Admiralty, by leading railway companies, public works contractors, etc. Free samples are supplied upon request.

Davis Bros., of 66 Deansgate, Manchester, have sent us a booklet descriptive of the "Apportioner" mixing machine, which they have just put on the market. This is an apparatus for automatically mixing dry materials of any description, cement, paints, chemicals, etc., and is claimed to produce a uniform composition at considerably less cost, power and trouble than has hitherto been possible. A standard machine is made with two 4-in. screws to mix two ingredients, and will deal with 15 cwt. per hour, more or less, according to the character and proportion of the materials. Machines will also be designed for special requirements to mix up to eight separate ingredients, and of capacities ranging from 5 cwt. to 20 tons per hour.

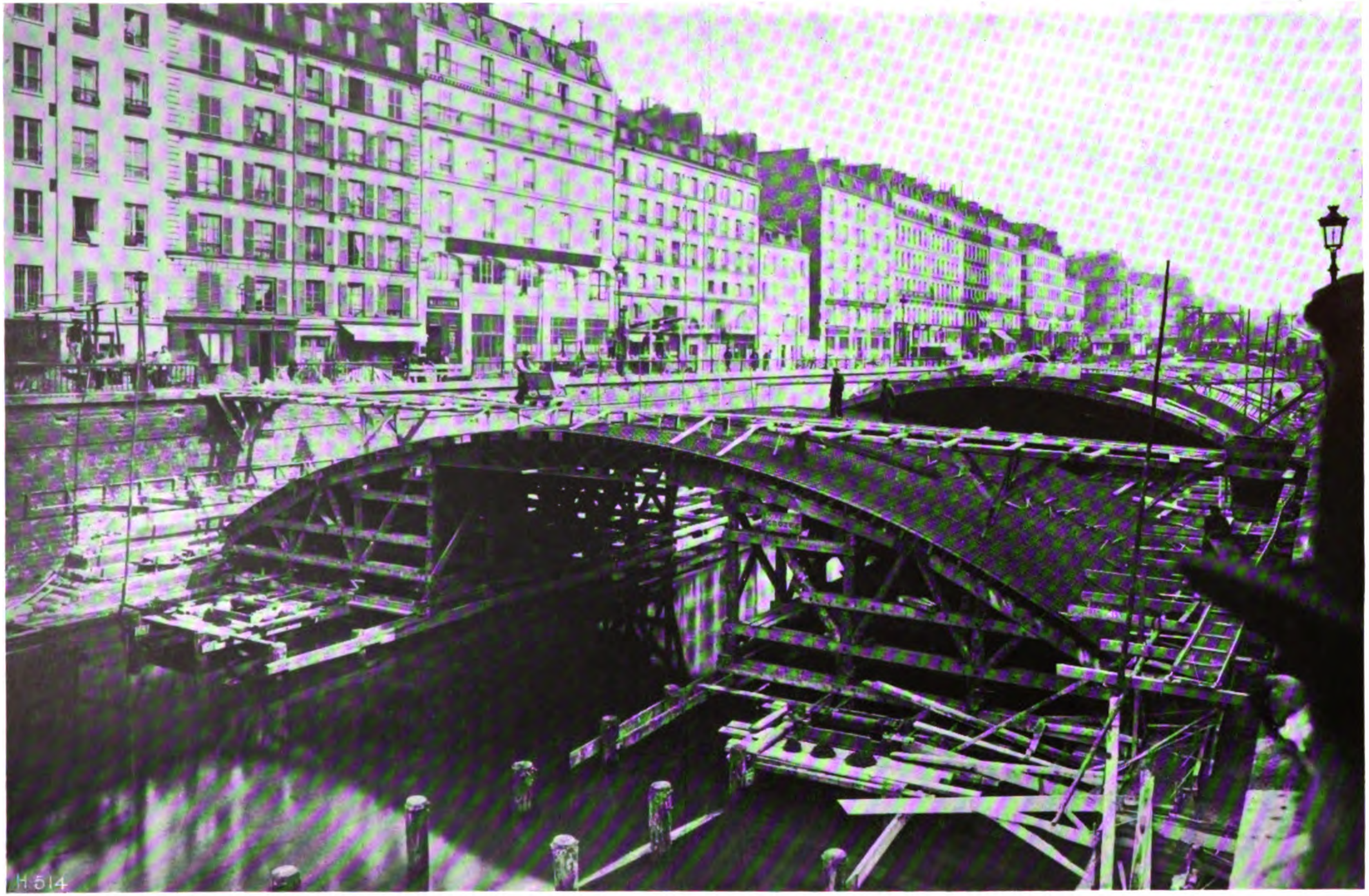
The British Uralite Co. (1908), Ltd.—We are advised that Mr. J. J. S. Davidson has resigned the managing directorship of the British Uralite Co., Ltd., of London and Higham, as, owing to his other engagements, he is unable to continue to give the close personal attention that the interests of the Company demand. Mr. Davidson is not severing his connection with the Company entirely, as he will continue to act as a director. Under his management the Company has been put on a sound financial basis; the factory has been reorganised, new markets have been developed for Uralite at payable prices, and the manufacture of Asbestone has been initiated to compete with the cheap Continental materials.

Mr. Arthur Koppel, 27 Clement's Lane, London, E.C., maker of concrete mixers, railway plant and installations, etc., informs us that, having amalgamated with the firm of Orenstein & Koppel, the full title of the firm will in future be Orenstein & Koppel—Arthur Koppel (Amalgamated).

CONTRACTS.

Messrs. D. G. Somerville & Co., 116 Victoria Street, S.W., have the following contracts in hand: Higham-Hellesdon Bridge for Norwich Corporation; Mendham Bridge for Norfolk and Suffolk County Council; Bosmere Bridge for Suffolk County Council; Lea Bridge for Benskin's Brewery; wharf at Portslade for J. E. Butt & Sons; new printing works at Brunswick Street, Blackfriars; starch factory at Ayr; lamp factory at Southfields; retaining walls at Mappin & Webb's, Queen Victoria Street, E.C., and R. Clay & Sons, Ltd., Blackfriars; new house for George Edwardes, Marylebone; nurses' home at Norwich; new schools for Kent Education Committee, Sheerness; building, High Street, Kensington; rinks at Maida Vale and Plymouth; water tower, Leicester; building, Finchley.

Messrs. Stuart's Granolithic Co., Ltd., of 4 Fenchurch Street, E.C., inform us that orders have been placed with them for reinforced concrete structures during the last month: Two more factories at Hayes, Middlesex; extensions to Maltina Bakeries, Blackfriars; new block at the Royal Hospital, Sheffield—to be called the Eldon Block; University Liverpool, block of buildings for the Students' Union; reservoir at Bury, Lancs; silos for cotton seed, Stoneferry; silos for grain at Barry Dock; schools at Rossall, Fleetwood.



View of work in progress.
ROOFING OVER THE CANAL ST. MARTIN, PARIS.

Frontispiece.
(Opp. Contents.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 6. LONDON, JUNE, 1910.

EDITORIAL NOTES.

SPECIAL USES FOR REINFORCED CONCRETE.

WHILST the progress made throughout the British Empire in the application of reinforced concrete to structures both above and below ground has been satisfactory, and a yet more rapid development is in sight, owing to the fact that the technical professions concerned have a better understanding of the material than heretofore, we regret to observe that reinforced concrete is not yet being used to that extent that we should expect for what we would term minor purposes. Abroad, particularly in Germany, Italy, and the United States, the progress in this direction has been very rapid, and the economies thereby obtainable are well appreciated not only amongst the technical professions, but by the public authorities, and what is even more important, by the " man in the street."

The reinforced concrete fence post, railway sleeper, telegraph pole, and electric light standard, etc., are notable and conspicuous examples of the practicability and economy of the new material. Reinforced concrete drain-pipes, water conduits, tanks, and cisterns are becoming as common as their predecessors constructed either of clay or metal.

For the everyday uses of the farm, estate, and other country purposes generally the development has been most remarkable, for wherever a suitable aggregate can be found, and where Portland cement is within easy reach, the necessary metal reinforcements seem to be forthcoming, crude as they may occasionally be, but the results are most useful. Capital expenditure is saved and maintenance expenditure reduced to a minimum.

We have from time to time published numerous examples of the application of reinforced concrete to these many minor and specialist uses, and, as far as farms and estates are concerned, we have, as a rule, selected examples from the United States, where the development in this particular direction is the most extensive. We would most strongly recommend the immediate and careful study of the subject to all concerned ; and here we would specially point to those in authority with our great corporations, railway and carrying companies, and our estate and agricultural concerns.

There cannot be the slightest doubt, that for the majority of the purposes named the advantages of using reinforced concrete quite outweigh those of materials such as metal and timber. Economy is a matter of the utmost importance at the moment, both as far as capital expenditure and maintenance are concerned, and one way of effecting substantial economies is to follow the example set in the United States, Italy, and Germany, by applying reinforced concrete for those numerous minor purposes to which we here refer.

STANDARD NOTATION.

ON looking through the recent papers and reports presented at this year's meeting of the Cement Users' Association of the United States, as well as of several other societies interested in reinforced concrete, we have been struck by the fact that the proposals made at the meeting of the International Commission on Reinforced Concrete, held last autumn at Copenhagen, did not appear to be receiving that attention which they merit, and this regardless of the fact that amongst those present were Professor Talbot and Mr. Humphreys.

The latter gentleman, it may be remembered, is the President of the Cement Users' Association for the year, and also the secretary of the American Joint Committee on Reinforced Concrete, while Professor Talbot has all that weight which experience and the highest standing in his profession have given to him, not only in the United States but also in Europe.

It would, indeed, be regrettable with the impending issue of numerous reports in the United States, and we believe also the publication of several official pocket-books on the subject of reinforced concrete, if some immediate effort were not made to assimilate the notations of the United States of America and those suggested for Great Britain.

We would put it to those interested, both on this side and in the United States, that the matter is now becoming one of urgency, and energetic and prompt interchange of views is essential if any good is to be done. We hold that if the present opportunity is missed by undue procrastination it may be irretrievably lost, for once given the publication of a large number of reports and pocket-books in the United States, all adopting an international notation different from that of Great Britain and its Colonies, it is unlikely that as time goes on there will be any tendency on the part of our American cousins to make a change, whilst at the present moment there is still an opportunity for getting things into line.

WATERPROOFING OF CONCRETE.

A CONSIDERABLE amount has been written during the last two years on the various forms of waterproofing concrete, and the more important contributions presented on the subject have been reproduced in these columns. An industry is now gradually growing up in waterproofing compounds, and we wish to draw the attention of those interested to this very useful departure in concrete practice.

The merits of the various compounds are well deserving of examination. Some of them lend themselves to the work in a general way, others have special advantages for meeting special conditions. The subject is, of course, comparatively new, and the experience obtained only extends for a limited number of years, but with the high development of chemistry to-day, the careful methods of testing, and the painstaking way in which the industries concerned prepare their products, we have every confidence that we are on the high road to the general adoption of waterproofing compounds in everyday structural practice, and we welcome what we consider to be a most useful innovation.

RETAINING WALLS.

By HENRY ADAMS, M.Inst.C.E.

Economy in space has become a most important question where deep retaining walls are used in city property, and there is no doubt that with the advent of reinforced concrete there will be a very considerable saving of space where structures of this description are concerned.

The interesting contribution presented below from the pen of Professor Henry Adams gives useful examples of work of this description.—ED.

Up to about the year 1860, retaining walls were generally constructed of brick or stone masonry in mass, of which *Fig.* 1 (Plate I.) is typical, but during the next ten years various modifications were made to reduce the quantity by a more scientific distribution of the material—*e.g.*, by arching over counterforts in stages, by heavy buttresses with vertical arches between, etc. About 1870, mass concrete was commonly used for retaining walls, relying for stability upon its weight, the centre of gravity being kept as far back as possible as in the case of the earlier brick and masonry walls. *Fig.* 2 (Plate I.) shows a concrete wall with brick parapet, constructed about 1879, at Mildmay Park Station on the North London Railway. *Fig.* 3 (Plate I.) shows a heavy concrete retaining wall built to sustain a surcharge. *Fig.* 4 (Plate I.) shows a lighter wall with batter front and back. *Fig.* 5 (Plate I.) shows the retaining wall at Messrs. Cockerell & Co.'s Wharf, Blackfriars. Many concrete retaining walls followed these early ones, and, in course of time, certain difficulties and defects became apparent.

In order to prevent unsightly irregular cracks, it was found necessary to make a vertical joint about every 60 ft. in heavy walls and 30 ft. in light walls to eliminate the stresses due to changes of temperature. In some cases the joints were plain vertical faces from front to back, and in others, a vertical groove and tongue about 12 in. wide were formed in the abutting faces of the joint. With reference to this matter, Thomas Potter, in "Concrete, its uses in Building" (Batsford), says: "Concrete retaining walls—*i.e.*, walls which uphold or retain the natural or artificial ground on one side, are not so liable to develop cracks as ordinary walls, because they are exposed to climatic influence on one side only, and so maintain a more uniform temperature. All the same, they do occur, and for this reason some engineers insert a thin piece of wood or sheet iron vertically, from top to bottom of walls, and at fixed distances apart. These are only carried a few inches into the wall, and fair or flush with the surface; when the concrete is dry they are withdrawn, and the space filled up with mortar or cement. This space probably opens and closes more or less when exposed to extremes of temperature, but is scarcely an eyesore in the sense that an irregular-shaped crack would be; it is thought that the shrinkage does not affect the wall beyond the space divided by the wood or iron strip, but that the former retains a sound condition. Sometimes, where it is not practicable to store cement a sufficient time to season it, low walls will show horizontal fissures or cracks between each 'lift' or layer of concrete, or where the latter has been left for a time before another deposit has been made. These are caused by the unseasoned cement swelling and bringing about the same result as the use of hot lime; we often see the lime constituent of the cement oozing through these cracks or fissures in the form of milk of lime. Concrete retaining embankment walls of railways have many of these unsightly horizontal fissures."

Before describing the modern reinforced concrete walls, reference may be made to a very large one of mass concrete recently constructed at Los Angeles. It is 600 ft. long, 52 ft. 8 in. maximum height down to a minimum of 13 ft., and is surmounted by a 5 ft. parapet. The foundation at maximum height of wall is 14 ft. wide, and the wall 8 ft. to 3 ft. at base of parapet. It was constructed in 40-ft. sections, no two adjoining sections being built at the same time. The expansion and contraction joints alternate, a distance of 80 ft. existing between two expansion joints or two contraction joints. The expansion joints were made by nailing sheeting across the end of the section, and properly bracing it; the expansion joints were reinforced with pilasters. The contraction joints were formed midway between the pilasters by bringing the end of one section of the wall up to a true vertical plane at a right angle with the central line of the wall.

An early form of reinforced concrete retaining wall is shown in *Fig.* 6 (Plate I.), which is a typical cross-section of some walls built by the Chicago, Burlington and Quincy Railway. The very moderate amount of reinforcement necessitated the retaining of a fairly large mass of concrete. *Fig.* 7 (Plate II.) shows a somewhat similar wall combined with a fence, built by the Michigan Central Railroad Co., but in this case the reinforcement was more to ensure the stability of the fence than the wall, as the wall would probably have been quite efficient without it. To provide for any unequal character of the foundation, six 1-in. square rods were placed longitudinally at the bottom of its broad footing. According to the *Engineering Record*, the fence surmounting the wall is a 6-in. continuous vertical slab 7 ft. high, that is built with both faces smooth. This slab is reinforced 1·25 in. from both faces with a plane of ½-in. square rods, spaced vertically 1 ft. apart on centres and extending from its top down into the wall. The rods near the rear face are carried entirely to the bottom of the wall, while those in front terminate directly above the footing. The fence slab thus is anchored thoroughly to the wall, it also is reinforced longitudinally by three pairs of horizontal ½-in. rods, one pair near the bottom, a second midway of its height, and the third just below the top, as shown in the drawing. These longitudinal rods are added chiefly to provide for temperature stresses, although they are of considerable value in strengthening the slab. Expansion joints are placed 25 ft. apart in the wall to confine to definite points the opening that may be caused by temperature changes or settlement. The longitudinal rods in the slab, and three horizontal rods near both faces of the wall, are broken at these joints. The concrete in the wall and fence was made quite wet, in the proportions of one part cement, 2·5 parts sand, and 4·5

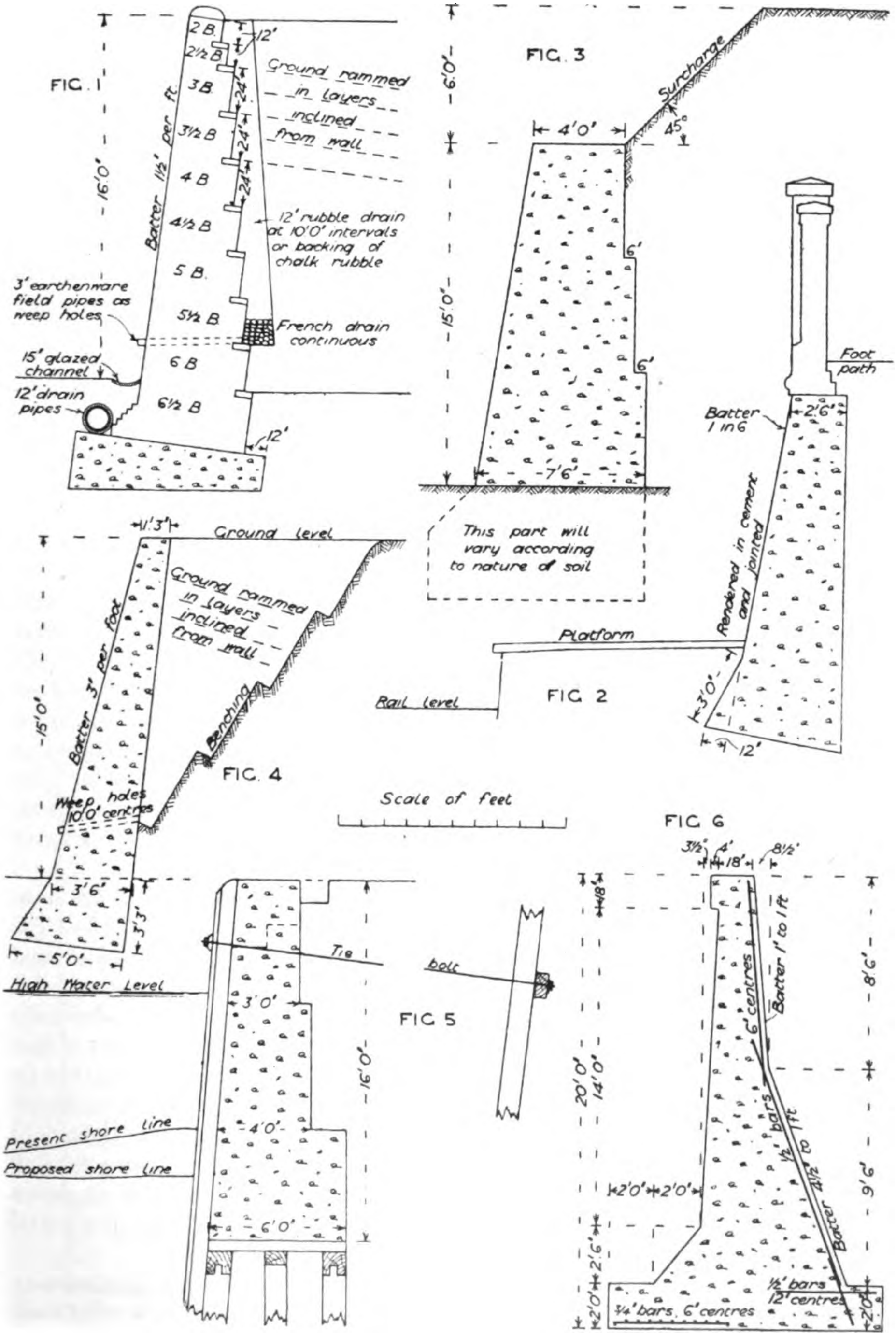


Plate I. Details of Retaining Walls.

parts broken stone ranging in size from ¾-in. pieces to those which would pass a screen with 1·5-in. meshes.

Fig. 8 (Plate II.) shows the type of wall designed by Mr. C. E. Rork, of the Steptoe Valley Smelting & Mining Co. He also constructed a designing diagram from which the section for any given height could be readily obtained. Details of this diagram were given in the *Engineering Record* for 19th February, 1910. The advantages claimed were: (1) Economy of work and time in the drafting office; (2) economy of excavation; (3) the toe being outside avoids either undercutting, where the ground is of such a nature as to admit of that, or filling in if the ground has to be cut away to get at an inside return toe or heel; (4) the outside toe serves as part of the floor, where that is to be of concrete, and thus saves material; (5) the form work is of the simplest and allows of repeated re-use of forms.

Fig. 9 (Plate II.) shows a simple reinforced concrete wall of L section, where the weight of the earth causing the thrust helps to hold the wall in position against the thrust. It was at one time thought that this form was not economical for greater heights than 12 ft., but Mr. F. A. Bone, of Cincinnati, has shown that they are suitable up to as much as 36 ft. high. Where the foundation was liable to compression, or where it was desired to avoid excavation at the rear of the wall, the section of an inverted T as shown in *Fig.* 10 (Plate II.) was found preferable. In this design the wall has absolutely no tendency to overturn with any load not greater than that assumed, and has no tendency to unequal settlement as the pressure is equally distributed over the foundation. The resistance of this wall to sliding forward on the base is less than in *Fig.* 9, as the weight is less. The tendency to slide is not excessive, as the angle of friction is but 23°. However, to make the resistance equal to that of the gravity wall, a key is extended into the foundation. The construction of this type of wall is much simpler than for a counterfort wall. The forms cost less than for a concrete wall of the same section as the gravity wall shown at *Fig.* 3. The reinforcing is all simple, with no bent rods.

A very good form of section for an independent retaining wall was that adopted in the Royal Liver Building, Liverpool, shown in *Fig.* 11 (Plate II.). The foundation slab is bordered by retaining walls of this section extending all round the site, thus converting the basement of the building into a huge watertight compartment, virtually identical so far as regards construction with a waterworks reservoir of more than 6,000,000 gallons capacity. One incidental result is that the lowest storey will always be perfectly dry, and therefore quite suitable for offices and the storage of papers. This is a point of considerable practical importance in view of the fact that the subsoil water level sometimes rises to the height of 10 ft. above the basement floor line. The wall consists of a 5 in. vertical slab with a continuous coping 18 in. wide by 8 in. deep, an extended base as shown by the drawing, vertical counterforts at short intervals apart, and horizontal ribs projecting from the slab and connected with the counterforts.

Fig. 12 (Plate II.) shows the section adopted by the Delaware, Lackawanna & Western Railroad at Buffalo. It consists of an L section with reinforced counterforts, which are called buttresses by the American engineers.

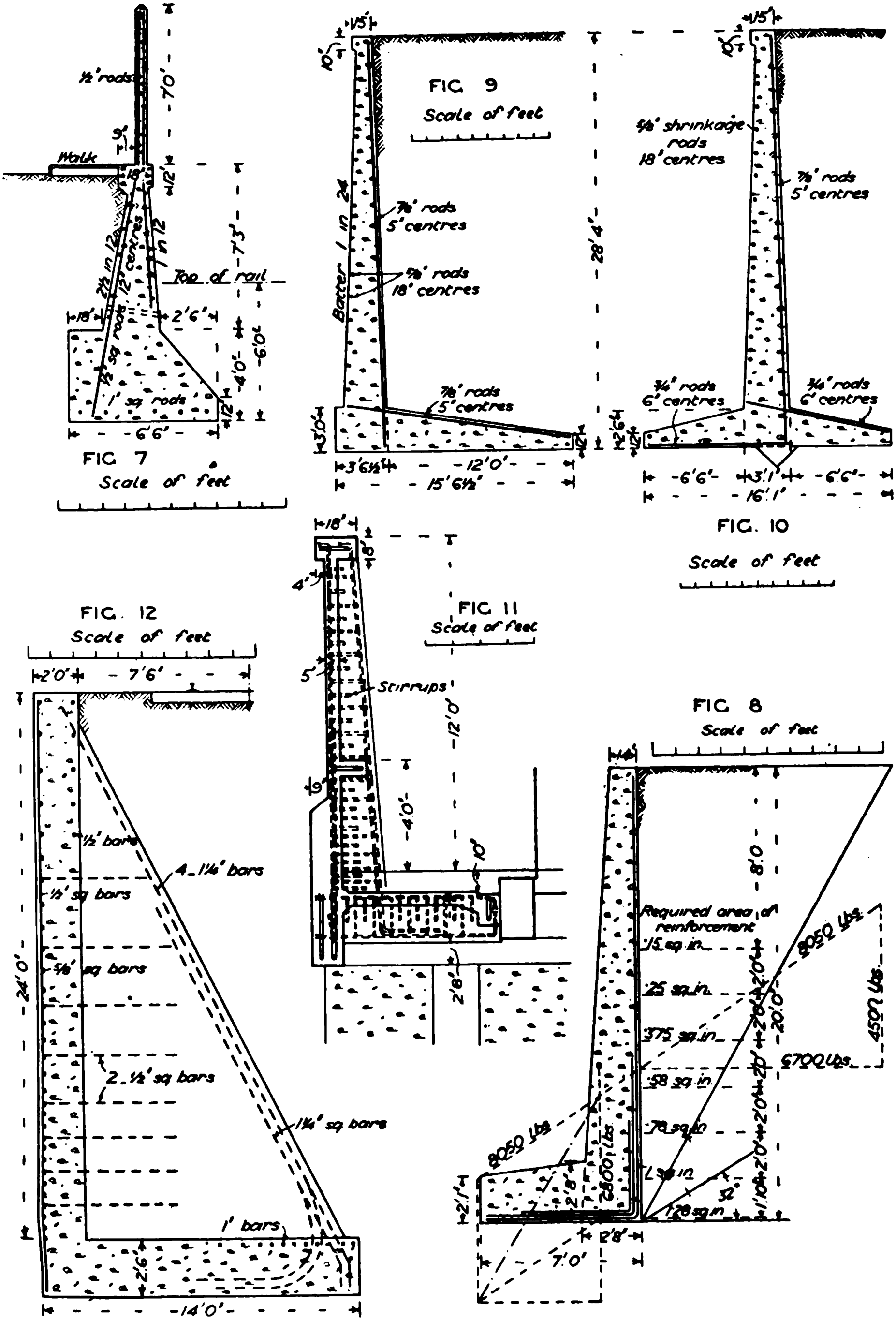


PLATE II. DETAILS OF RETAINING WALLS.

The tracks were placed near retaining walls only where the buttressed section was used, the distance from the centre of the track to the back of the wall in no case being less than 7 ft. 6 in. No tracks whatever were close to the section without buttresses. the retained fill having a long slope up to the road-bed level. The earth pressure against the walls, which are 2 ft. thick, was figured according to the formulas in Church's Mechanics, the height of earth being taken at 100 lb. per cubic ft. The weight of concrete was taken at 150 lb. The pressure due to the moving loads on the tracks was figured for Cooper's E 50 loading. The width of the base for the buttressed type was taken as half the height of the wall above the top of the base plus 2 ft., and for the L section as half the distance from the top of the base to a point where a vertical line through the inner edge of the base intersects the slope line, the slope being 1½ : 1. The base is 2 ft. 6 in. thick. The stresses in the steel were kept under 16,000 lb. per square inch, and in the concrete under 500 lb.

The reinforcement of the buttressed section consists of both horizontal and vertical bars near the face of the wall, horizontal bars in the base and inclined bars in the buttresses, square mild steel being used in all cases. Those laid horizontally in the face of the wall are of ⅝-in. material spaced on different centres, farther apart at the top and closer at the bottom, to take care of the increasing pressures toward the bottom of the wall. The vertical bars in the front face are of ½-in. material spaced throughout on 2-ft. centres. In the back face five ½-in. bars have been placed on 18-in. centres. There are tie rods from the wall into each buttress, two of them being looped over every third of the horizontal face bars. They are 6 ft. long and ½ in. square. The heaviest bars used on the work, 1¼ in. square, are used for the diagonals in the buttresses. There are eight of these, but only four run the entire distance from the top of the wall to the outer end of the base, the others starting at intermediate points. At the bottom of the buttresses, four of the diagonal bars are bent back toward the wall and are embedded near the under side of the base. Running longitudinally in the top of the latter are 1-in. square bars, in the outer half of the footings. The rods in the face do not come closer than 2½ in. to the surface of the concrete, and those in the buttresses and in the base not closer than 3½ in.

In order to preserve the proper spacing for the horizontal bars in the face, a 2-in. by 2-in. by $\frac{3}{16}$-in. angle is placed in the face at each buttress, holes being punched in one leg to hold the bars in their proper positions. They are left in place and form part of the permanent reinforcement of the wall. The horizontal bars are on 18-in. centres for the first 6 ft. down from the top, on 12-in. centres for the next 6 ft., on 9-in. centres for the next 5 ft. 3 in., and on 6-in. centres for the remainder of the distance to the bottom of the wall.

The reinforcement for the sections below 24 ft. and above 12 ft. in height is substantially the same for all sections, except that the base would be moved upward, cutting off the lower part of the reinforcement shown in the diagram, so that from the top down, for any given distance, the steel will be the same in walls of all heights.

The buttresses are 2 ft. wide and 12 ft. 6 in. on centres. In the original design it was intended to place an expansion joint every 25 ft., or on the centre

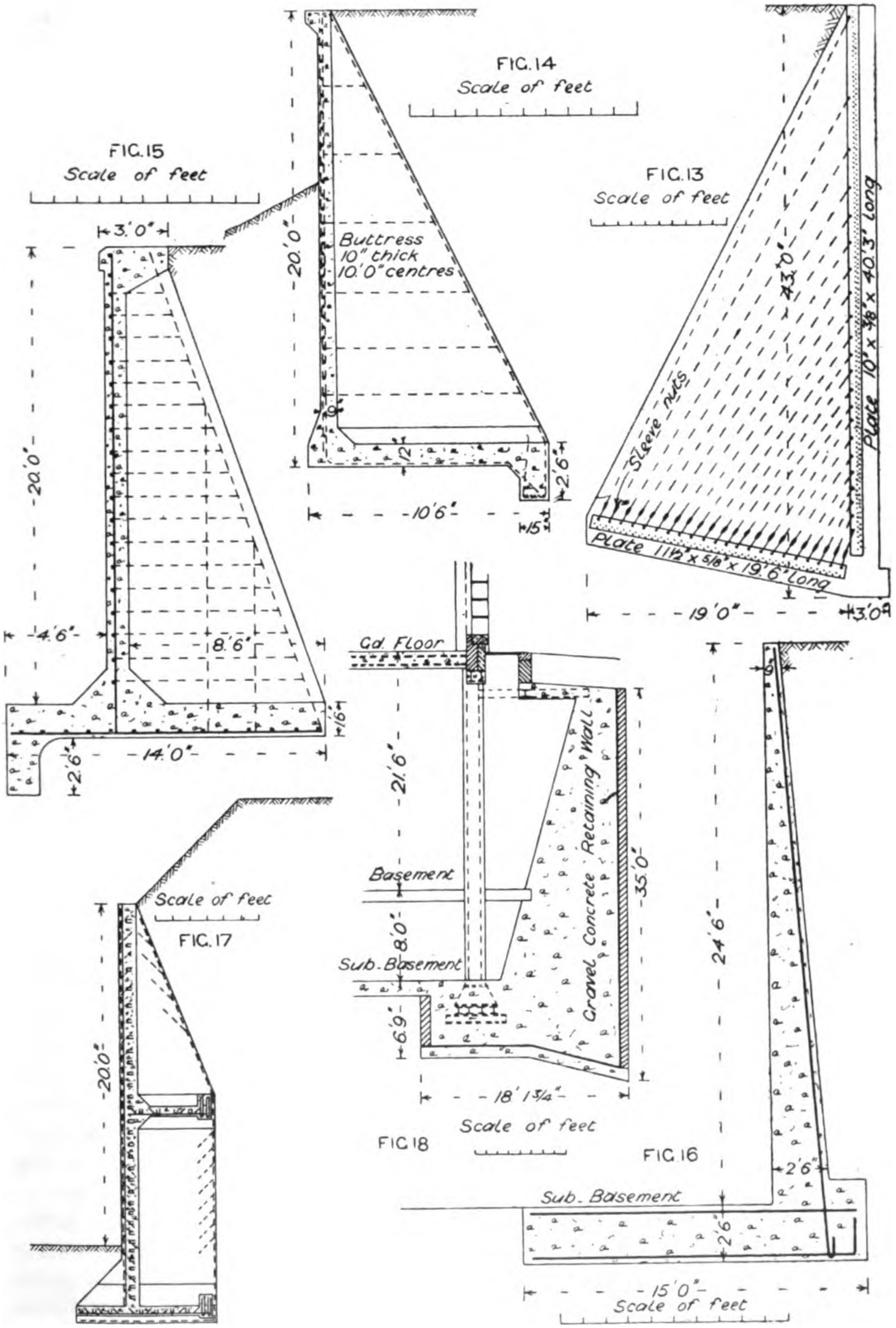


PLATE III. DETAILS OF RETAINING WALLS.

line of every second buttress. When construction was started, however, it was found that the wall could be more economically placed in 50-ft. than in 25-ft. sections, and it was therefore decided to place the expansion joints every 50 ft., so that the day's work could be made to terminate at an expansion joint.

All of the horizontal bars are 28 ft. long, while the others, necessarily, are cut to shorter lengths in accordance with their positions. The concrete was a 1 : 3 : 6 mixture made with gravel.

Fig. 13 (Plate III.) shows the section of a reinforced concrete retaining wall about 220 ft. long with a maximum height in the centre of 64 ft. exclusive of a 4-ft. parapet wall constructed by the Department of Public Works at Pittsburg. The wall spans a gulley which was formerly crossed by a timber trestle bridge. Briefly stated, the wall consists of a reinforced concrete face and footings or floor, with reinforced counterforts at frequent intervals. The character of the ground introduced some complications into the design of the footings, and between successive counterforts hardly any two slopes of the footings are alike, the maximum being about 38° parallel with the length of the wall, and about 30° transversely. The footings were sloped transversely instead of being made horizontal, not only to save excavation, but also to save concrete. The ground consists of a layer of loose material, beneath which is a bed of excellent shale, on which the footings are founded. The floor between the counterforts is 2 ft. thick, the front wall 18 in. thick through its full height, and the counterforts 1 ft. thick. The concrete in the floor and the foundations consists of 1 : 2½ : 5 mixture ; and in the face wall, parapet and counterforts a 1 : 2 : 4 mixture, the sand being washed river sand, and the aggregate gravel. The reinforced concrete portion of the wall has not been carried across the entire length of the hollow, there being a plain concrete gravity section 18 ft. long on the east end, and 22 ft. long on the west end. Two vertical expansion joints have been provided at approximately the third points in the length of the wall, 74 ft. apart. These expansion joints are V-shaped, and filled with three thicknesses of heavily-tarred paper.

The reinforcement consists of round rods varying in diameter from ½ to 1⅝ in., and anchored to plates embedded in the floor and in the face of the wall by nuts and pins. These anchor plates are all ⅝ in. thick, and are 8, 8½ or 11½ in. wide, depending upon the height of the wall where they are used. One of these plates runs the entire length of the floor embedded in the latter under each counterfort, and another plate is embedded vertically in the wall in the same plane with the floor plate and the centre line of the counterfort. These two plates are tied together by round rods varying in diameter from 1¼ in. at the lowest section of the wall to 1⅝ in. at the highest, their spacing and number being naturally dependent on the earth filling which they are to retain, the weight of the latter varying, of course, with the height of the section. At each end of these rods there is a forked eye, and the connection is made to the plates by means of pins, which, after being driven, are held in position by two split cotter pins. In the lowest section of the wall twelve 1-in. round rods are used, their spacing in the anchor plate embedded in the floor being 9¼ in. on centres. From the floor anchor plates the rods spread out, the pins which connect them to the vertical anchor plates in

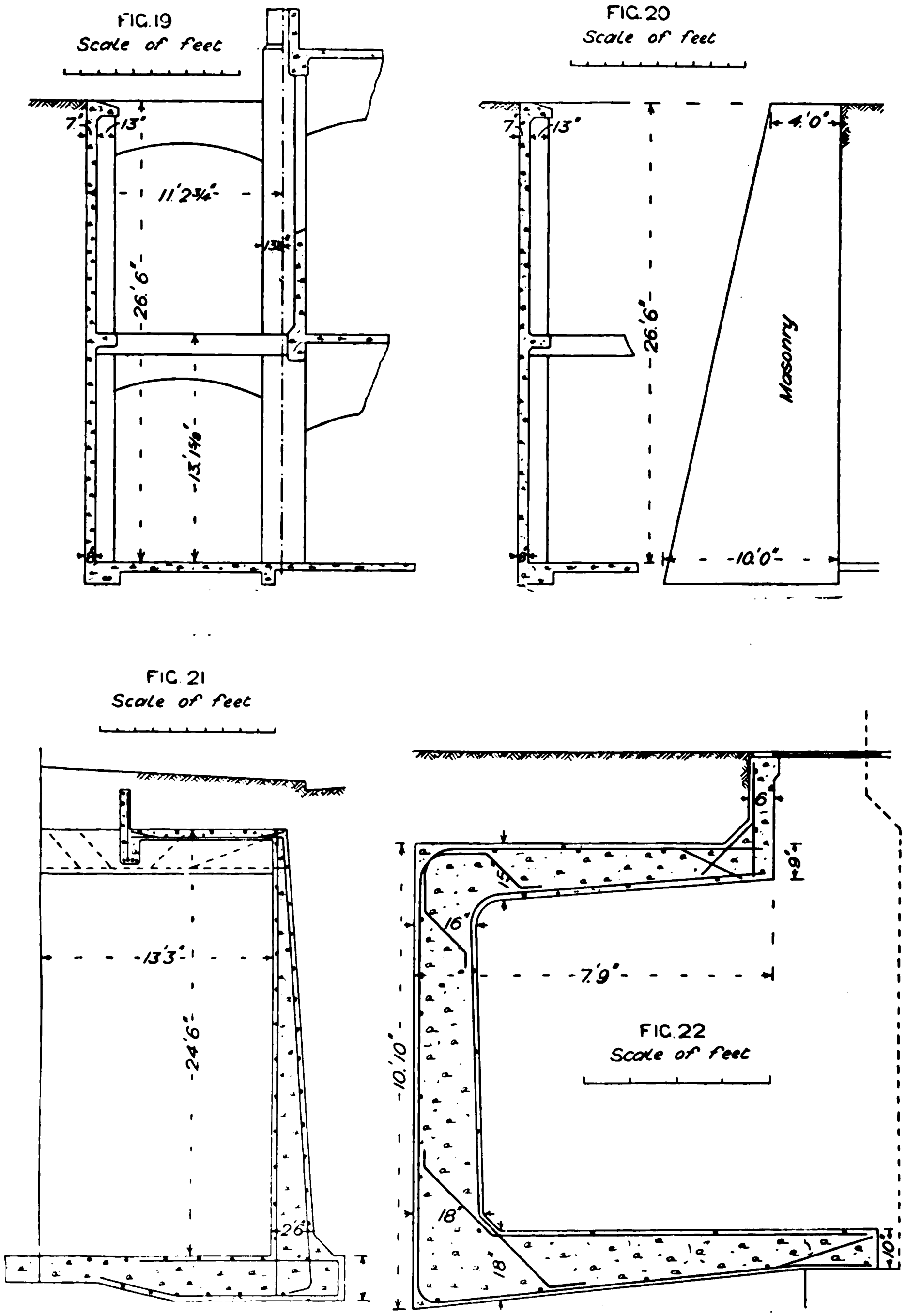


FIG. 19
Scale of feet

FIG. 20
Scale of feet

FIG. 21
Scale of feet

FIG. 22
Scale of feet

Plate IV. Details of Retaining Walls.

the wall being 13 in. apart at the bottom and 41½ in. apart at the top, varying gradually between these two values. In the highest section of the wall there are forty-two 1⅝-in. round rods embedded in the counterfort, their connections to the floor anchor plate being 8¼ in. apart, and in the wall anchor plate 10 in. at the bottom and 6 ft. 3 in. at the top, varying, as described for the lower section, between these two values. The pins used in connecting the rods to the plates vary from 1½ to 2⅛ in. in diameter.

The floor rods in any given sections between two adjacent counterforts are all of the same diameter, varying from nineteen 1¼-in. rods where the wall is lowest, to fifty-three 1¼-in. rods where it is highest. Rods of smaller size have been used in some of the other panels, and the required total section made up by using a larger number of rods. The anchor plates have three lines of holes punched in them, the upper line in the floor anchor plate being for the connection with the tie rods running through the counterfort, and the other two lines for the reinforcing rods in the floors. All of the floor rods on one side of the counterfort are connected through one line of holes, the rods on the other side being connected through the other line of holes. Nuts are used on the ends of all of the reinforcing rods in the floor and in the wall. The length of the footings varies from 9 ft. to 29 ft. 6 in. in length, and the spacing of the reinforcing rods in them is always uniform in any given panel. All of the rods are bent downward, and though the tops of the floor anchor plates are about on a level with the floor itself, the rods come within a few inches of the bottom of the concrete footings.

The reinforcing rods in the face of the wall are of the same general type as those used in the floor, and are passed through the vertical anchor plates, in the planes of the counterforts, and held in place by means of nuts. Each rod spans between two adjacent counterforts. They vary in diameter from ⅞ in. at the bottom to ½ in. at the top, the spacing increasing from the bottom upward to suit the varying pressure of the earth backing. This spacing varies from 3 in. at the bottom of the highest section of the wall to 6 in. at the top of the same section. The number of the reinforcing rods in the face varies from 53 in the end panels to 151 at the centre.

The counterforts are spaced 10 ft. apart on centres, except at the two expansion joints, where they are on 4-ft. centres. They are all 1 ft. wide and enclose the tie rods which connect the anchor plates in the floor and the face.

Fig. 14 (Plate III.) shows a section of a retaining wall for a 50-ft. roadway by the Indented Steel Bar Co., Ltd., and *Fig.* 15 (Plate III.) a somewhat similar wall with counterforts and apron given by Mr. P. H. Palmer in *The Surveyor*, 14th July, 1905.

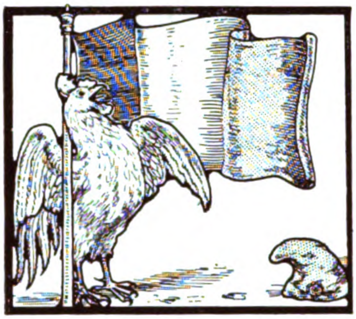
The retaining wall of the Royal Insurance Co.'s building at the corner of St. James's Street, Piccadilly, is shown in *Fig.* 16 (Plate III.). The wall is 24 ft. 6 in. deep from top to sub-basement level, and only 30 in. thick at bottom, tapering to 9 in. at the top. The reinforcement for the vertical part of the wall consisted of 1¼-in. indented steel bars spaced 4½ in. apart for a height of 14 ft., and the remainder of the height 13½ in. apart, every third bar being carried to the full height. A double system of similar reinforcement, spaced 4½ in. apart, was introduced into the horizontal portion of the wall, and binding bars, which are not shown, were inserted in the front edge to assist the concrete in taking the compressive stresses. The concrete was all machine mixed, and consisted of 1 cement, 2 sand, 5 Thames ballast graded from ¾ in. to ¼ in.

A retaining wall on the Kahn system of reinforcement is shown in *Fig.* 17 (Plate III.); this may be compared with the mass concrete wall having a similar surcharge shown in *Fig.* 3 (Plate I.). The intermediate shelf on the back of the wall, dividing into two portions the wedge of earth which produces the thrust, reduces the thrust by about one-half. In the *Morning Post* building, in Aldwych, London, although steel frame construction was utilised for the general building and foundations, the retaining wall which surrounded the site was only of mass concrete. It had, however, some novel features, as shown by *Fig.* 18 (Plate III.). The toe of the wall gives increased resistance to sliding, and the stanchions being placed upon the foot of the walls give additional stability. A brick wall was first built against the soil and then waterproofed by mastic asphalt, the concrete being afterwards deposited within shuttering. The danger of letting in the street, by reason of the proximity of the tunnel through which the London County Council trams run, and the Gaiety Theatre and Hotel, necessitated great care in the work, and only small portions at the time could be constructed; an efficient bond between the different lengths was, however, obtained by leaving a V-shaped groove at each junction.

In the General Post Office extension, carried out under Sir Henry Tanner upon the Hennebique system, the retaining walls, shown in outline in *Fig.* 19 (Plate IV.), were strutted by the lower floor, and therefore became equivalent to the flat plates in the sides of a tank. The panels were only 7 in. thick at the top, and 8 in. thick at the bottom, with a total height of 26 ft. 6 in., whereas a solid brick retaining wall would have needed to be about 8 or 10 ft. thick at the base; the comparison of the two sections given in the *Builder*, 3rd April, 1910, and shown in *Fig.* 20 (Plate IV.), indicate the striking advantage of using reinforced concrete in this manner.

A further departure from normal methods of constructing retaining walls was carried out at the Royal Insurance Offices in Piccadilly, London, by which much valuable space is saved. This consisted in forming the vaults under the pavement in conjunction with the wall, as shown in *Fig.* 21 (Plate IV.). A very similar arrangement appears in Messrs. Mappin & Webb's premises at the corner of Cheapside, London, just completed, where the double cantilever arrangement is still more pronounced, as shown in *Fig.* 22 (Plate IV.).

This summary of the development of retaining walls has shown the very great advantages obtained by the adoption of reinforced concrete, and these advantages, consisting of a saving of cost, space and time, without any sacrifice of durability, assure a successful future for this method of construction.



THE CONCRETE INSTITUTE: VISIT TO PARIS.

By F. E. Wentworth-Sheilds, M.Inst.C.E.
Hon. Sec. of the deputation.

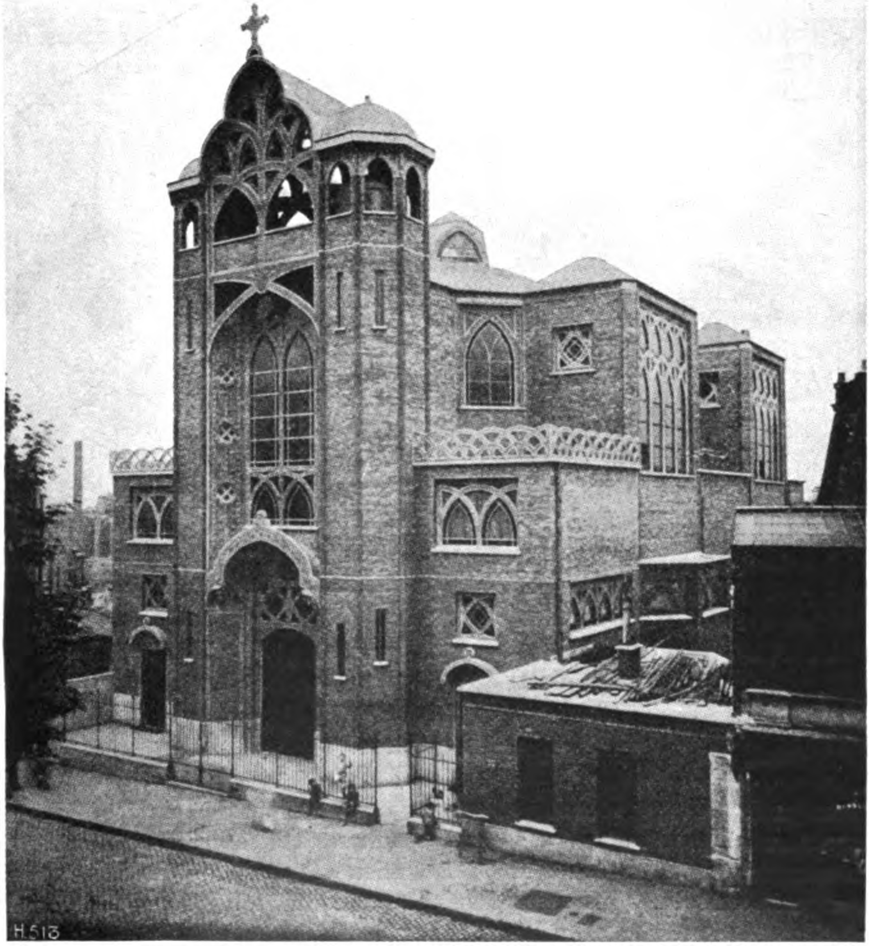
We are very pleased to be able to give some particulars of the recent visit paid by a deputation from the Concrete Institute to Paris, which was undertaken to inspect some of the earlier examples of reinforced concrete, to ascertain the durability of this material. We hope at a later date to be able to publish the report of the Institute on the various structures inspected.—ED.

A SERIES of meetings, the importance of which can hardly be overestimated, was held in Paris during the month of April, when a deputation from the Concrete Institute was invited to visit that city and to examine several most interesting works in reinforced concrete which have been constructed there during the latter half of the last century. The deputation consisted of Sir Henry Tanner, I.S.O., F.R.I.B.A. (Vice-President of the Institute), Mr. C. H. Colson, M.Inst.C.E. (Admiralty Works Department), Mr. William Dunn, F.R.I.B.A., Mr. W. G. Kirkaldy, Mr. A. Ross, M.Inst.C.E. (Chief Engineer Great Northern Railway), Mr. J. S. E. de Vesian, M.Inst.C.E., Mr. F. E. Wentworth-Sheilds, M.Inst.C.E. (Docks Engineer, Southampton), Mr. E. P. Wells, J.P. (Hon. Treasurer of the Institute), Mr. H. K. Dyson (Secretary), Mr. H. K. G. Bamber, Captain Gibson-Fleming, R.E., Mr. Fred A. White (Chairman of the Associated Portland Cement Manufacturers (1900) Ltd.), Mr. G. C. Workman, Mr. P. W. Leslie, Mr. Harold H. D. Anderson, and Mr. P. M. Fraser.

The programme of visits was arranged by Monsieur Rabut, Engineer-in-Chief of the French State Railways, who has himself designed and carried out some notable works in the new building material, and who has done much to popularise its use among the famous Government Corps of Engineers (Les Ingénieurs des Ponts et Chaussées), of which he is a distinguished member. Besides having control of all the new works on the State Railways, M. Rabut is a professor in the school where the students of the corps receive their training; and it may be here pointed out that the next generation of French Government Engineers will derive immense advantage from having studied under one who has so thoroughly mastered not only the theory but also the practice of reinforced concrete design.

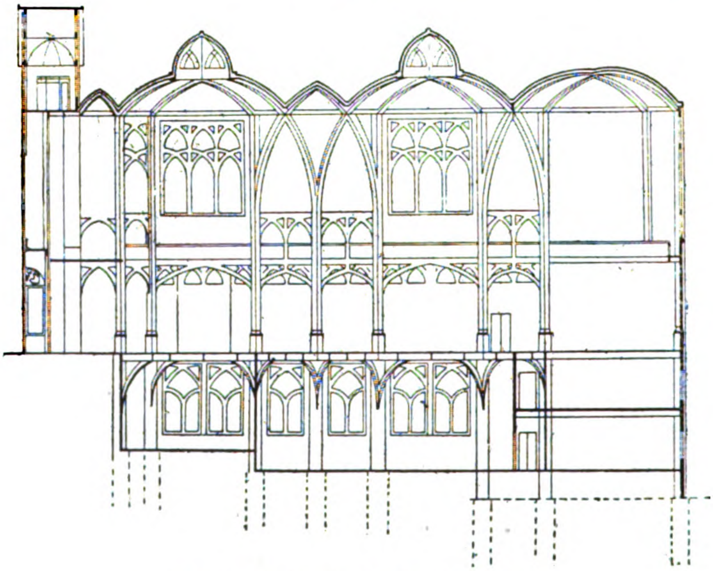
M. Rabut had been specially asked by the deputation to show them works in reinforced concrete which had been in existence for a number of years, and which had been exposed to changes of climate, moisture, and other trying conditions. Accordingly he put himself into communication with other French engineers who have specialised in this material, and prepared a programme of visits which occupied two long days, during which a number of structures unique in their variety and ingenuity of design were inspected.

The first morning a start was made by visiting the church of St. Jean de Montmartre, in Paris. This was shown by the architect, M. de Baudot, who occupies the position of Inspector-General of Historic Monuments to the French Government. Unfortunately Monsieur Cottançin, who had carried out the work on the system which bears his name, was unable to be present. As will be seen from the longitudinal section on page 396, the church is built on steeply sloping ground, and the eastern end contains a basement, which is itself a fine chapel. The church, which is built partly of brickwork and partly of concrete, both reinforced, is about 38 metres (125 ft.) long and 28 metres (92 ft.) wide,



View of west front.
CHURCH OF ST. JEAN DE MONTMARTRE, PARIS.

and with a total height of about 30½ metres (100 ft.). The principal building is approached from the main street, where a fine view of the west front is obtained. The curious flat effect of the façade, with its parapet looking as if it were made of lace, and the light belfry tower surmounting it, at once betray the fact that unusual building materials have been employed. The walls are of very thin red brickwork, the bricks being hollow, and reinforced horizontally and vertically with steel wires on the Cottançin system. The columns and arches are red brick casings surrounding a reinforced concrete core. The roof vaulting and the floor are of reinforced concrete. The interlaced arches of the balustrade and of the belfry tower are made with the same material and pleasantly decorated. The whole is a marvellous piece of light and strong design. M. de Baudot has paid much attention to the problem of decorating concrete, and has here produced very pleasing effects by a kind of bold mosaic of coloured pottery discs fastened on to the concrete surface. He claims that the church, which was built in 1896, has cost far less than any building of its size could have done if carried out in other materials, and certainly £16,000 for such a large building seems to be a moderate sum.

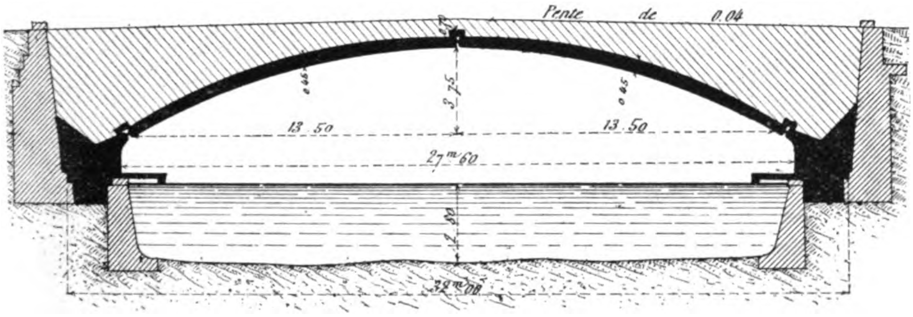


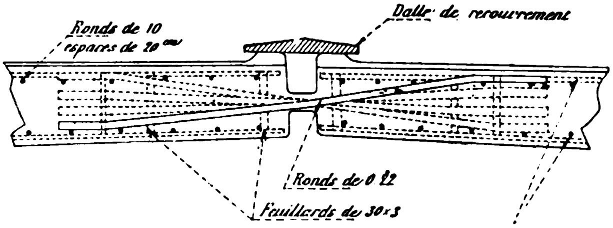
Longitudinal section, showing chapel in basement.

Church of St. Jean de Montmartre, Paris.

The deputation next passed on to the Canal St. Martin, a portion of which (le Basin du Temple) was roofed over three years ago with a reinforced concrete arch, which is remarkable in many ways. The canal at this point is in a cutting, the total depth from the ground surface being about 9 metres (30 ft.). The sides of the basin were originally formed of masonry retaining walls, arranged as shown in the accompanying cross-section, which gives the principal dimensions of the structure. The new roofing has a span of 27·60 metres (90 ft.) and a total length of 240 metres (790 ft.). To provide for any slight subsidence of the abutments, which were supported on the old retaining walls, the arch, which is 45 cm. (18 in.) thick, is provided with three continuous joints ("semi-articulations") of peculiar design. These joints were formed by a series of special bars nearly (but not quite) circumferential, which crossed each other in such a manner that all passed through the centre of the joint. The detail drawing explains this clearly. The ordinary circumferential reinforcement, consisting of round bars above and below, 16 mm. (½ in.) diameter and 20 cm. (7¾ in.) apart, stopped short on either side of these joints. As a precaution the arch is stiffened with reinforced concrete ribs at intervals of 13 metres (43 ft.), although it is estimated to be sufficiently strong without these ribs. The cost of the arch and its foundations was about £26,000. Above the roofing the ground is filled in to a level surface, while the towing paths below are carried on cantilever slabs of reinforced concrete.

Cross section of roofing.





Detail of joint.

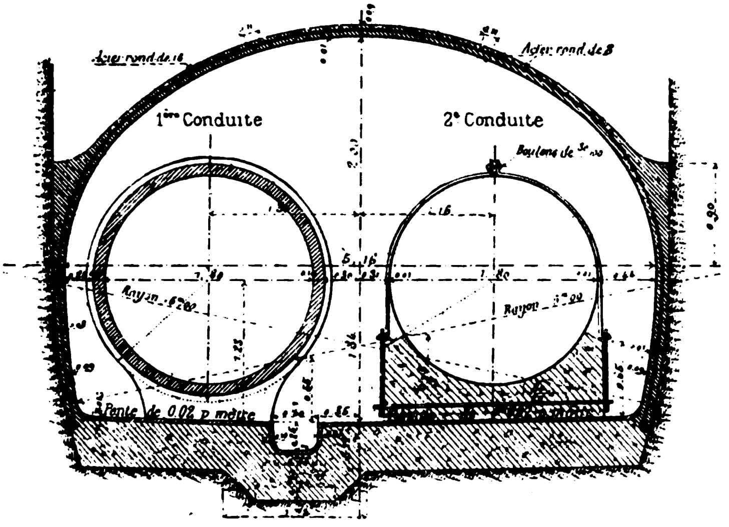
Canal St. Martin, Paris.

In the afternoon a visit was paid to a most interesting house at St. Denis, built no less than 58 years ago by the elder Coignet, who is claimed to be the inventor of reinforced concrete in the modern sense of the word. Certainly he seems to have been one of the first who clearly understood the part played by the reinforcement in his structures. The house in question is a three-storey building about 20 metres (65 ft.) by 14 metres (46 ft.). The roof consists of a slab of reinforced concrete about 30 cm. (1 ft.) in thickness resting on brick walls. By means of partition walls the unsupported span of any portion of the roof is reduced to about 6 metres (20 ft.). The concrete, curiously enough, is a mixture of very fine gravel and hydraulic lime and cement mixed in the proportions of 5 : 1 : ½. The reinforcement consists of H-bars about 8 cm. (3 in.) deep, placed near the underside of the slab so as to take the tension. The concrete was broken into in the presence of the deputation, and it was found that both the steel and concrete were in excellent condition. A large number of small contraction cracks were to be seen in the surface, which had apparently been stopped up with cement. There was no rendering or any sort of covering on the roof, however, and inquiries made from those who were living in the house elicited the fact that the roof is perfectly watertight in all weathers. The house was shown by the son of the famous builder, M. Edmond Coignet, who is himself well known as having designed and erected many important structures in reinforced concrete.

Built by François Coignet in 1852.
Roof of House at St. Denis.

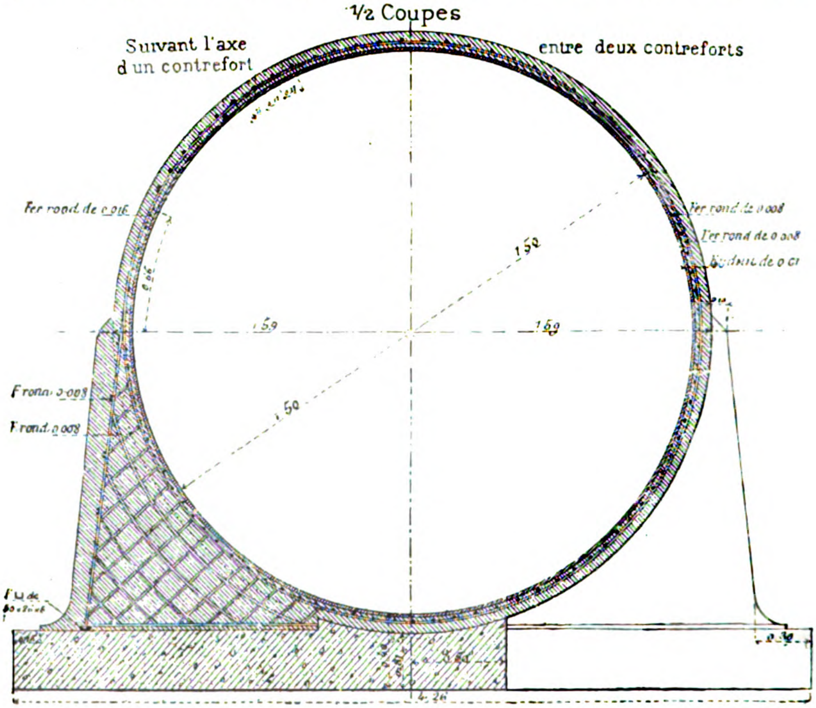
Later in the afternoon the deputation were invited to see the famous sewage disposal works of Paris, and these proved to be full of interest to the student of reinforced concrete. The Engineer-in-Charge, M. Bechmann, Ingénieur en Chef des Ponts et Chaussées, and M. Coignet and M. Bonna, who are responsible for the details and for the execution of many of the works, arranged the programme. Briefly, the sewers of Paris are led to Clichy, where the first main pumping station is placed. Here the pumps force the sewage through a syphon under the River Seine into a gravitation culvert leading to Colombes, where another pumping station is situated. At this point the pumps send the sewage across the river again, this time on a bridge, and then through a pair of rising mains, whose length is about 2½ kilometres (1½ miles), with a total lift of about 34 metres (111 ft.). Thence it passes into a single gravitation culvert of 3 metres (10 ft.) diameter, and with a length of about 6½ kilometres (4 miles). After that the ground falls rapidly down to the irrigation farm at Achères, and the sewer falls with the ground. At this descent the sewage is carried in two pipes, each of 1·00 metres (3 ft. 3 in.) diameter. At the base of the slope the pipes pass once more under the river, and thence into branch pipes, which connect with the distributing feeders of the irrigation ground of Achères.

Reinforced concrete has been very largely used throughout the whole of this main sewerage system. For instance, the long rising mains which lead from the second pumping station at Colombes consist of two pipes, each 1·80 metres (6 ft.) diameter, built inside a cut and cover tunnel, which serves to give access to the pipes. This tunnel is entirely of reinforced concrete. Its length is about 2½ kilometres (1½ miles). It is almost semi-elliptical in form, and its cross-section is shown on the accompanying figure. It has a width of 5·16 metres (17 ft.) and a height of 3·34 metres (11 ft.). The floor is made of a slab of plain concrete of varying thickness, but the arch of reinforced concrete has a uniform thickness of 9 cm. (3½ in.). The reinforcement consists of round bars placed longitudinally and circumferentially. The skin is hardly concrete in the English sense of the word, but a mortar of cement and sand mixed in the proportions of about 1 to 3. This, moreover, is rendered inside with a mortar of Vassy cement and sand mixed in the proportions of about 1 to 1½. The result appears to be excellent, as the tunnel is absolutely dry, and after its 17 years' work shows no sign of distress. Within this tunnel are placed the two rising mains, each of 1·80 (6 ft.) diameter. The lower portions



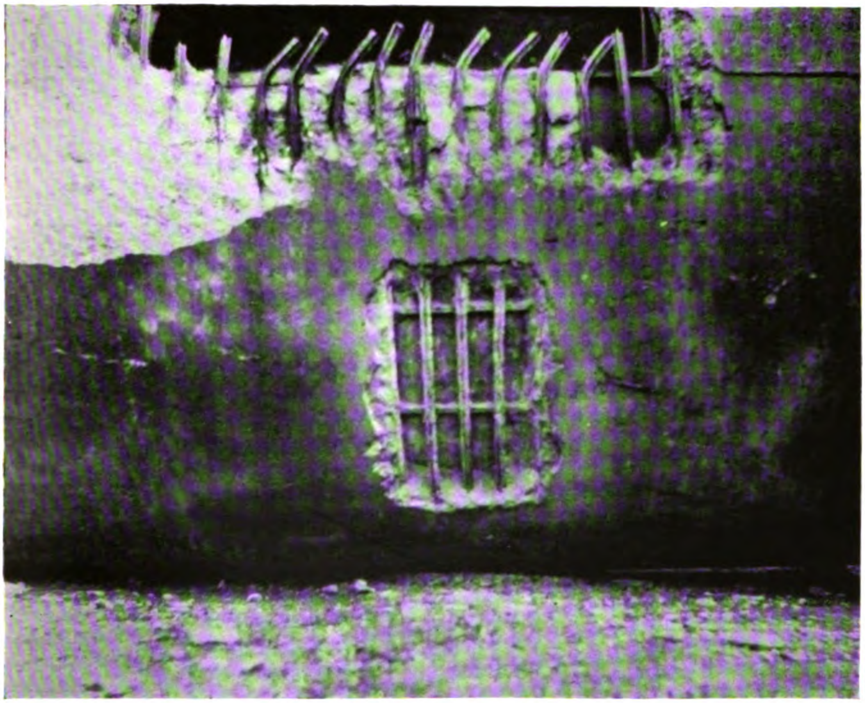
Cross section of tunnel containing two rising mains.
Paris Sewerage

of these mains, where the pressure is greatest, are made of plate steel. The upper portions are reinforced concrete pipes made on the Bonna system. These are designed to stand a maximum working head of 17 metres (56 ft.) at the lower end. They consist of a very thin steel tube, 4·5 to 3·5 mm. (0·18 to 0·14 in.) in thickness, which forms the internal lining of the pipe. Outside this steel tube is a skin of concrete or mortar 10 cm. (4 in.) in thickness, containing the reinforcement, which consists of bars of the cross-section used by M. Bonna, and which are placed both longitudinally and circumferentially. The pipes are cast in lengths of 2·50 metres (8 ft.), and each joint is covered by a collar of similar design to the pipes themselves. Each length of pipe is supported by a concrete saddle, which rests on the floor of the tunnel. At the top of the hill the two rising mains discharge into a single gravitation sewer, a portion of which is constructed of reinforced concrete. It consists of a barrel culvert 3 metres (10 ft.) in diameter and 9 cm. (3½ in.) thick, reinforced with round bars placed longitudinally and circumferentially. Here, again, the concrete consists of a mixture of cement and sand, and the culvert is rendered internally with a strong mortar 1 cm. (⅜ in.) thick. It is supported on saddles of reinforced concrete at intervals of 4·20 metres (14 ft.), which rest on a continuous slab of plain concrete 4¼ metres wide and of varying thickness. This part of the culvert stands above the surface of the ground. From the end of this gravita-



Cross section of large gravitation culvert.
PARIS SEWERAGE.

tion culvert the sewage once more enters a pair of cast-iron pipes, through which it is taken into the Seine Valley, crossing under the river once more to the irrigation ground at Achères. Here, again, the branch distributing pipes are of reinforced concrete on the Bonna system. The design of these latter pipes is slightly different, however. The thin steel tube is still preserved with the stiff reinforced concrete casing outside it. A casing of concrete is, however, provided inside the tube as well as out to ensure the preservation of the sheet steel. This inside lining is itself reinforced similarly to the exterior covering, but the section of the bars is much lighter. The thickness of the concrete is also less inside than outside. Pipes of all sizes from 1·10 metres (3 ft. 6 in.) to 0·30 metres (1 ft.) are made in this fashion to conduct the sewage to various parts of the irrigation ground. They are all cast in short lengths and laid in position, each joint being covered by a reinforced concrete collar.



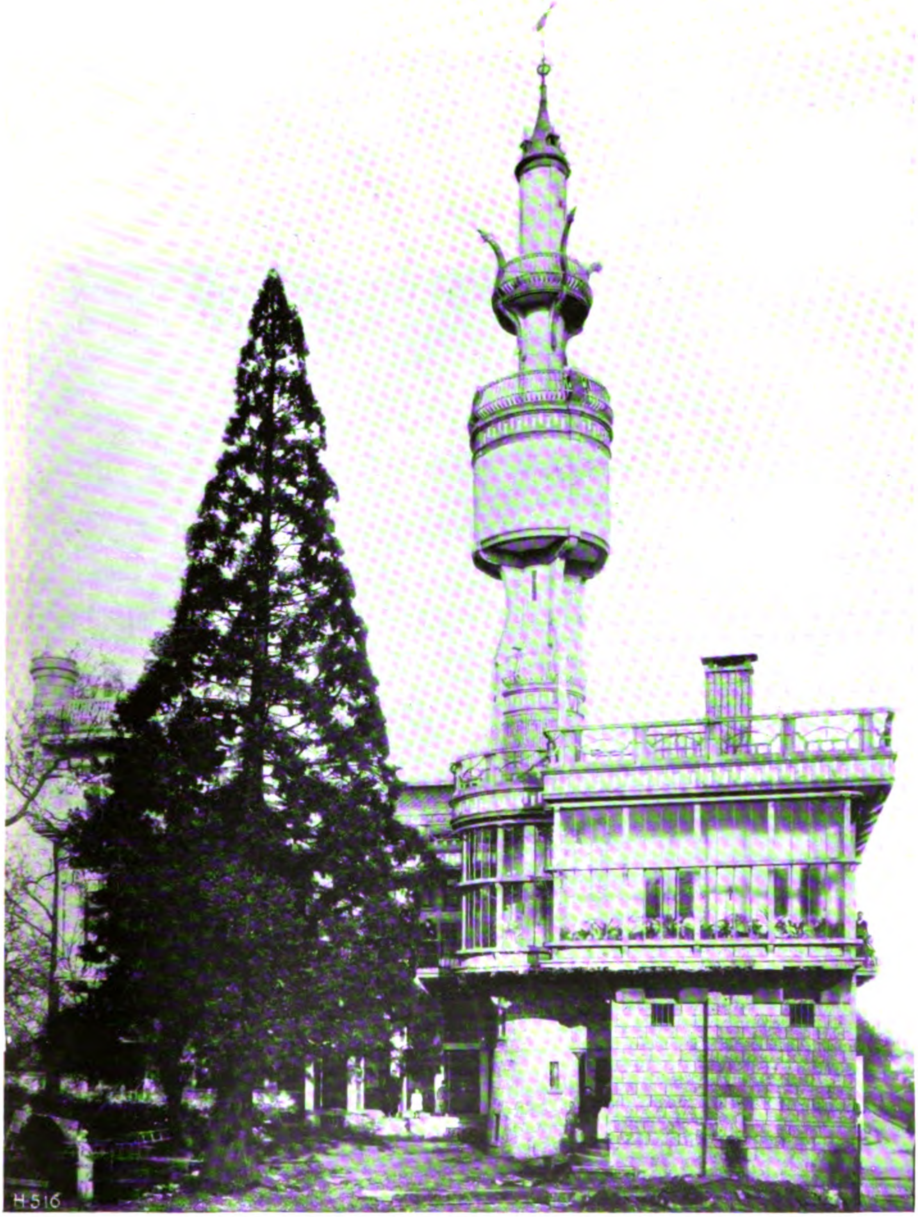
Cut into to show reinforcement.
BONNA PIPE 17 YEARS OLD.

Besides being used in the culverts and pipes here described reinforced concrete has been largely used at the pumping station at Clichy. A large quantity of the sewage is pumped into a circular tank (la Bâche de Gennevilliers), which is 6·20 metres (20 ft.) in diameter and 9·50 metres (31 ft.) high. This is formed of reinforced concrete 9 cm. (3½ in.) thick, surrounded on the outside with an ashlar masonry wall for the sake of appearance, as the tank stands wholly above ground. The rest of the sewage is discharged into a large rectangular tank with a circular end to it (la Bâche d'Achères). The rectangular portion is about 20 metres (66 ft.) by 8 metres (26 ft.), and the circular end is 6 metres

VILLA AT BOURG-LA-REINE.

(20 ft.) in diameter. This latter tank, which lies underground, is constructed of masonry, but is covered throughout with a flat roof of reinforced concrete.

On the second morning the party was invited by M. Hennebique, whose name is so well known in this country in connection with reinforced concrete,

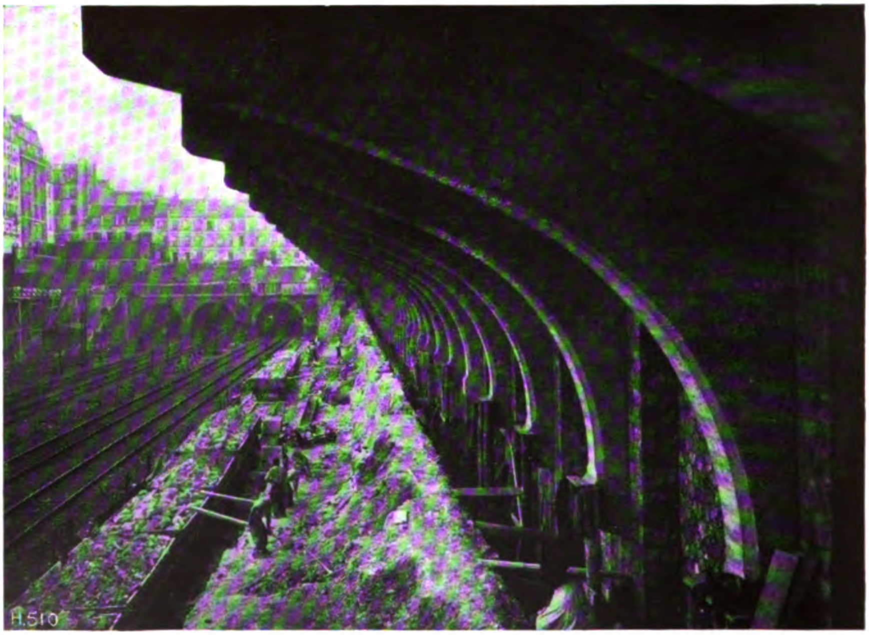


ANOTHER VIEW OF VILLA AT BOURG-LA-REINE.

to see his house in Paris, No. 1 Rue Danton. The building contains a very fine set of offices for the use of M. Hennebique and his staff. Later on they visited

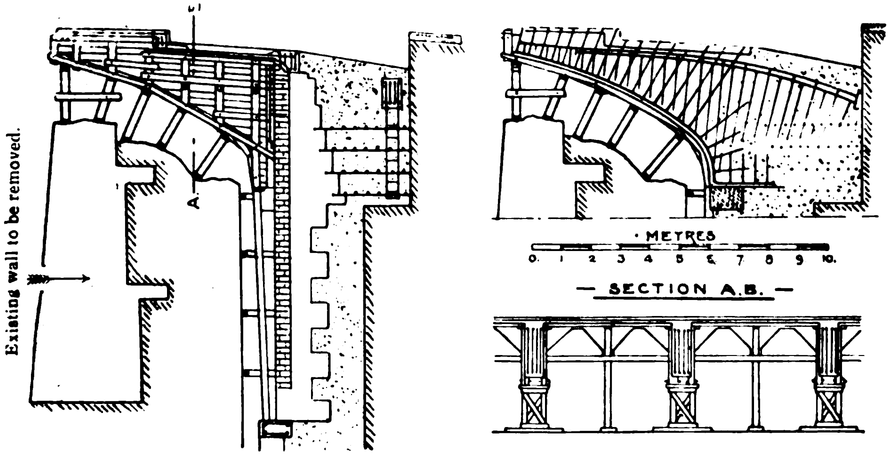
M. Hennebique's country house at Bourg-la-Reine, which is certainly a marvellous instance of what can be done with reinforced concrete. A glance at the accompanying illustrations will show some curious architectural features. The overhanging room at the left-hand side of the picture on page 402, and the high tower with its water tank, are, of course, effects which it would be almost impossible to obtain in any other material. It may be interesting to mention that the surface of this building is formed of very thin reinforced concrete slabs, in which coloured flints are embedded. The monotonous colour of concrete is thus pleasantly avoided at little or no expense, as the use of the slabs renders planking for moulds unnecessary.

In the afternoon the widening works of the Paris-Auteuil Railway were visited, under the guidance of M. Rabut, the Engineer-in-Chief. This is a line with exceedingly heavy traffic. Some ten years ago the number of lines of way was increased from two to four over a considerable length, and now works are in hand for a further widening. The line is largely built in two cut and cover tunnels, with upright masonry walls and flat roof, the span between the two walls being about 13 metres. In the older tunnels this roof was constructed of steelwork, but in the newer ones reinforced concrete has been freely used. The roofing consists of stout reinforced concrete T-beams, 80 cm. (2 ft. 9 in.) in depth and 2·50 metres (8 ft.) apart, the slabs being 30 cm. (1 ft.) in thickness. M. Rabut is quite satisfied with the suitability of reinforced concrete for such a position, although the conditions are extremely trying, as sulphurous smoke



View of retaining wall, with cantilevers to carry the steel above.
PARIS-AUTEUIL RAILWAY.

and steam from the engines are constantly being discharged on to the roof. On the other hand, he finds that the steel girder roofing of the older tunnels corrodes very rapidly, and he is gradually covering all these steel girders with a cloak of reinforced concrete. One of the most interesting works on the railway, however, is the cantilevers which are being constructed to carry an overhead roadway alongside the railway. The line at this point is in cutting, and was originally bounded by a masonry retaining wall, which supported the high-level roadway alongside. It became necessary to widen the line without disturbing the roadway. Accordingly a new masonry retaining wall under the centre of the roadway was built, from which projects a series of reinforced concrete cantilevers connected with concrete decking. These are tied back to a masonry counterbalance, which is built under the centre of the roadway. The drawing and photograph clearly illustrate this construction, which is a splendid example of M. Rabut's engineering skill, and there is much credit due to M. Hennebique, who has carried out the work for him. The cantilevers vary in length, the longest being as much as 7 metres (23 ft.).

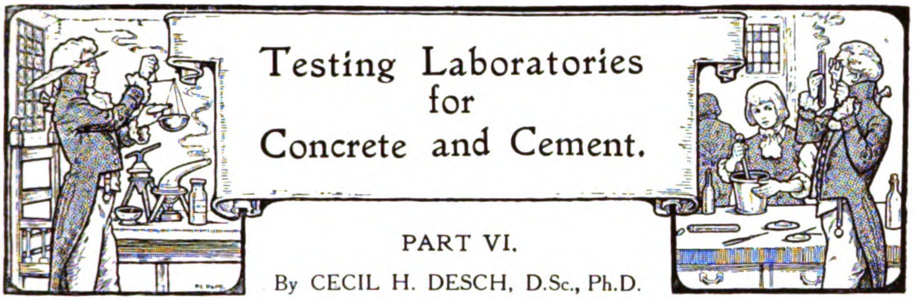


Cross section of retaining wall and cantilevers.

PARIS-AUTEUIL RAILWAY.

A very ingenious use of composite beams is being made by M. Rabut in the lengthening of certain over-bridges. One of the roads which cross over the railway is carried on six longitudinal plate girders of 40 metres (131 ft.) span, with substantial jack arches of brickwork in between them. Owing to the addition of two more lines of way this span has had to be increased to 48 metres (157 ft.). At first it was proposed to remove the girders and substitute other stronger ones in the usual way, but M. Rabut pointed out that it would be quite possible to make use of the existing girders, and merely lengthen them. This he said because in calculating the strength of the original girders no account was taken of the jack arches between the girders, which support the roadway, and in which the top flanges of the main girders are buried. In the light of our present knowledge, however, he considered it safe to assume that this mass of brickwork added very considerably to the strength of the steelwork, and that the span might safely be increased without renewing this steelwork. Accordingly the girders have been prolonged to the same design. Careful tests with traction engines and loaded wagons have been made, which show that the deflection is very considerably less than would have been the case if the brick arches did not exist, and that the bridge as widened is perfectly safe to take any load that may come upon it. It is evident that by thus utilising the existing girders an enormous economy has been effected.

While in Paris the deputation had the honour of being invited to meet the Association des Ingénieurs des Ponts et Chaussées at dinner. In the absence of M. L'Inspecteur-Général Guérard, the visitors were received by M. Colson, some time Inspecteur-Général des Ponts et Chaussées, and well known to Englishmen as a leading authority on inland navigation. The deputation were also very kindly entertained to luncheon by the Chambre Syndicale des Constructeurs en Ciment Armé, a society which includes nearly all the leading constructors in reinforced concrete in France. M. Edmond Coignet, the President, received the guests. They were also entertained by M. Hennebique at his house at Bourg-la-Reine. Before they left France an opportunity occurred of returning the hospitality of some of these gentlemen at a dinner party given by the deputation at the Hôtel de Crillon, where they had the pleasure of meeting M. Rabut and M. Mesnager (Ingénieurs en Chef des Ponts et Chaussées), M. Michel (Ingénieur of the Port of Honfleur), Professor le Chatelier and M. Feret, who are well known in connection with their research work on Portland cement, M. Hennebique, M. Coignet, and others. During their stay in Paris the members of the deputation were greatly impressed with the very cordial reception that they were accorded, and the anxiety on the part of their hosts to give them all possible information and facilities for seeing their works. They were also much struck by the boldness and originality displayed by the designs of French engineers.



Testing Laboratories for Concrete and Cement.

PART VI.

By CECIL H. DESCH, D.Sc., Ph.D.

The absence of an official laboratory devoted to investigations with concrete and cement may be said to account in no small degree for the dearth of reliable data as to reinforced concrete as designed and executed in this country.

Some testing station enjoying official support, or if conducted by some independent technical body at least enjoying official recognition, would be very much in place at the moment, and it might be a matter worthy of the attention of the Concrete Institute to consider the possibility, and ways and means of obtaining for the British Empire some laboratory of this description.

We have presented particulars of a number of laboratories in the preceding articles, and this article deals with one conducted as a private industrial enterprise, but enjoying the reputation of absolute reliability, and thus being frequently commissioned to undertake work for public departments.—ED.

Of the numerous important testing laboratories on the Continent, those of Berlin and Zurich have been described in former articles of this series. We are now enabled to publish some particulars of two national laboratories, situated in Copenhagen and in Rome, both of which embrace the testing of cement and concrete in their routine.

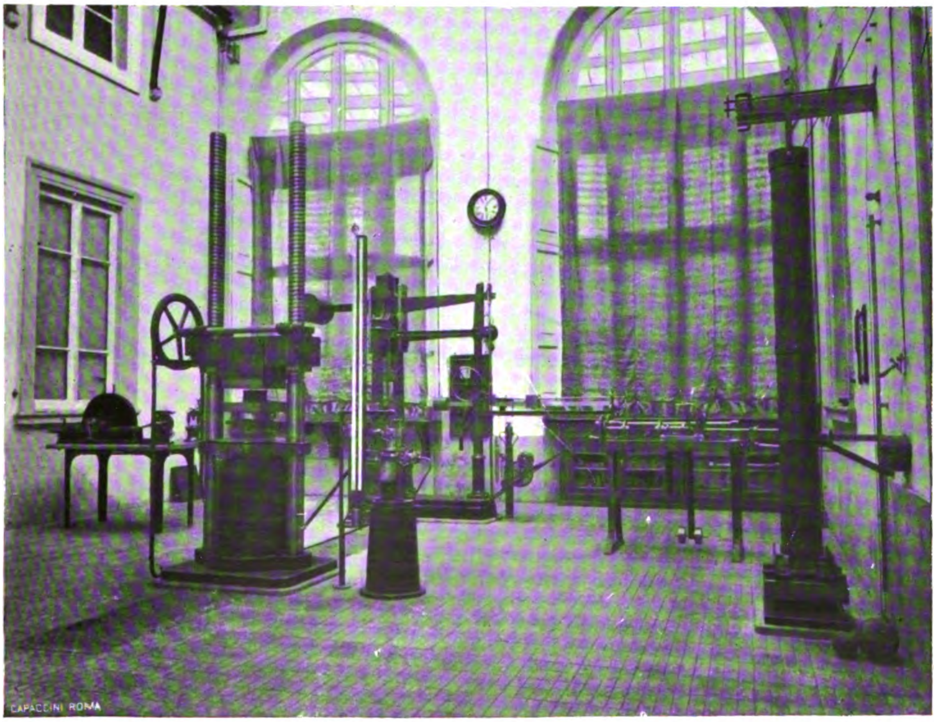


Fig. 1. Machine for Compression and Bending, of 250 tons Capacity, etc.
Italian State Testing Laboratory.

DANISH STATE TESTING LABORATORY.

An account of the Danish State Testing Laboratory in Copenhagen has been published in connection with the recent International meeting in that city. It appears that the earliest tests of the strength of materials, made with the object of controlling the processes of construction, are due to an officer of the Swedish army, Paul Würtz (1612-1676), who was of Danish birth.

Passing to modern times, we find that as early as 1858 the Danish Corps of Engineers began systematic tests of the properties of concrete for embankments and fortifications, with the result that concrete was adopted by them as the sole material for marine fortifications twenty years before it was employed by military authorities in other countries. The Danish State Testing Laboratory was established in 1896 by the Society of Civil Engineers, and in April, 1909, it became a Government institution. Although small in comparison with many other testing laboratories, it has already proved of great utility both to the State and to the industries of Denmark.

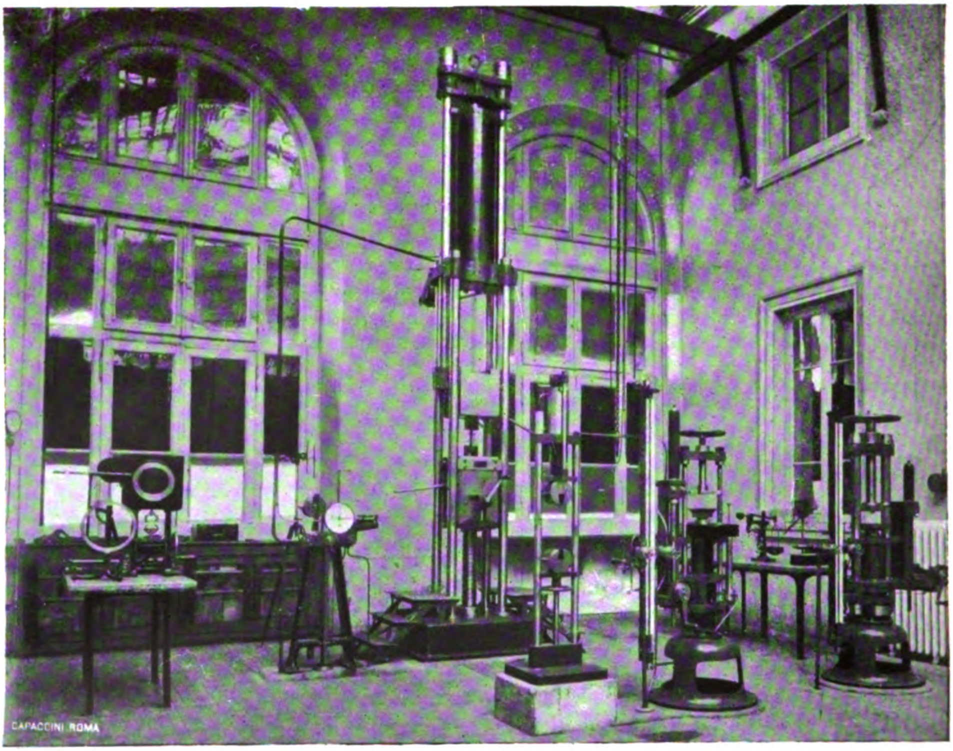


Fig. 2. Tensile Testing Machine of 150 tons, etc.
ITALIAN STATE TESTING LABORATORY.

The equipment includes a 32-ton hydraulic press by Amsler-Laffon, of Schaffhausen, a 50-ton machine for tensile, bending and compression tests, by T. Olsen, of Philadelphia, and a 120-ton Brinck and Hübner hydraulic press, besides smaller testing machines. In testing cements, regular use has been made of the accelerated test due to Erdmenger, in which both tensile and compressive test-pieces are tested after being heated for six hours in a boiler under a pressure of ten atmospheres. This test, rarely employed elsewhere, is often prescribed in Danish specifications. Transverse tests on prisms have been made as at Zürich. Several investigations in connection with the laboratory were communicated to the meeting of the International Association, and an account of the recent important tests of the influence of sea-water has appeared in CONCRETE AND CONSTRUCTIONAL ENGINEERING. Tests of fire-resisting materials have been made, the bricks or other materials to be tested being built up to form a chamber, heated internally by gas.

Tests of many kinds of bricks are made, including cement bricks, which have attained to some degree of importance in Denmark in the last few years. The tests include those of resistance to frost, which, however, cement bricks generally fail to pass. Concrete pipes which are too large for the testing machine are loaded by means of a simple lever arrangement, capable of testing pipes up to 32-in. diameter.

Researches, which have not yet been completed, have been made in order to deal with the problem of producing durable surfaces of coloured cement in the external decoration of buildings. The Thorvaldsen Museum in Copenhagen is decorated externally in inlaid coloured cements, and the different colours have shown very unequal degrees of resistance to weather, the yellow areas in particular having suffered badly. Although means of preventing the formation of fine fissures during setting, the principal initial cause of deterioration, have not yet been discovered, progress has been made in the choice of durable pigments, capable of resisting the alkalinity of the cement. A report has also been published on the most suitable paints for application to new cement surfaces.

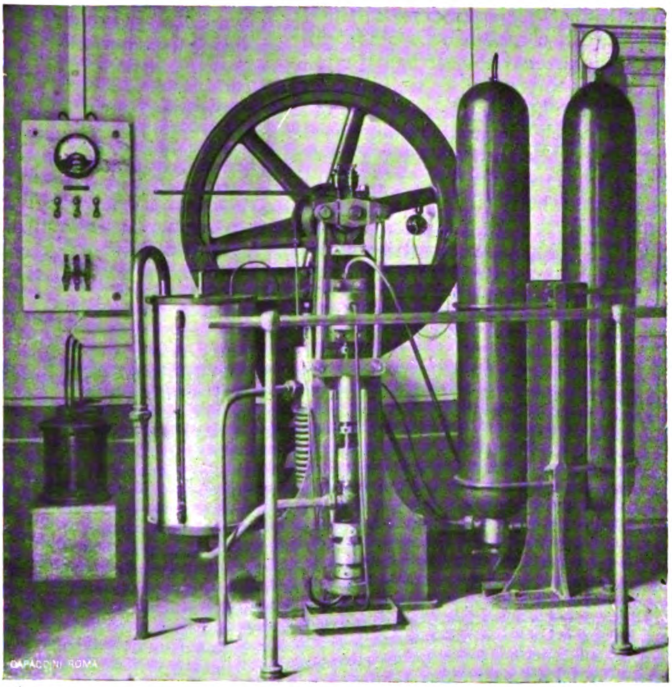


Fig. 3. Hydraulic Compressor.
ITALIAN STATE TESTING LABORATORY.

ITALIAN STATE TESTING LABORATORY.

The Experimental Institute in Rome is the central Testing Station of the Italian Department of State railways. It is housed in a large and well-arranged building, and is capable of dealing with the whole of the very great variety of materials required by the railways. The laboratories for the testing of cement and concrete, with which we are particularly concerned, are large and roomy. The equipment includes an Amsler-Laffon machine for compression and bending, of 250 tons capacity, and therefore capable of taking reinforced concrete beams and columns, a tensile testing machine of 150 tons, also by Amsler-Laffon, together with a similar machine of 30 tons. There is also a universal 50-ton machine by Mohr and Federhoff, of Mannheim, a 5-ton machine for tension and bending, and two 50-ton presses for cement cubes, all by Amsler-Laffon. All these machines are actuated by a central hydraulic compressor, electrically driven, and transmitting power by compression of olive oil. The general disposition of the larger machines is seen in *Figs.* 1 and 2, and the compressor in *Fig.* 3.

Cements are mixed mechanically in a Steinbrück mixer and rammed automatically. Fineness is determined with the aid of Tetmajer mechanical sieves, and setting time both by the Vicat needle and by Fantini's automatic modification of it. There is also an apparatus for measuring the development of heat during setting. Both the Le Chatelier and the micrometric methods are employed in the detection of expansion. The permeability of stone, concrete, etc., is tested in Tetmajer's apparatus, and the action of frost by means of a methyl chloride machine, constructed by Donane, of Paris, and shown in *Fig.* 4.

The chemical laboratories undertake the analysis of cements, sands and numerous other materials, and a complete microscopical equipment provides for the examination of such materials as are capable of being studied by this method, now gaining greater importance in respect to cement as well as in respect to metals.

A large part of the building is given up to the testing of electric motors, telegraphic apparatus, and other objects with which we are not directly concerned. Lastly, there is a very complete collection of specimens of constructional materials, with their recorded tests, and of models. Large though the Institute is, it delegates a great deal of testing to the subsidiary laboratories in Turin, Florence and Palermo. The organisation of public testing has been recently referred to in this journal, in a report on the steps taken in European countries to ensure uniformity of testing.

We are indebted to our contemporary, the *Ingegneria Ferroviaria* of Rome for our illustrations.

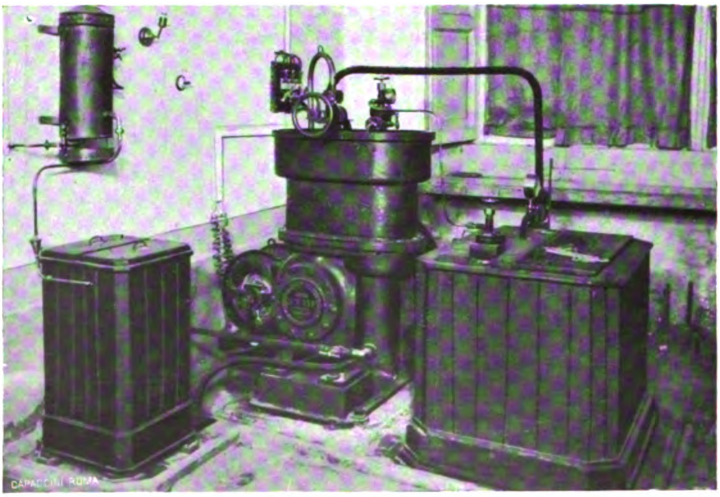
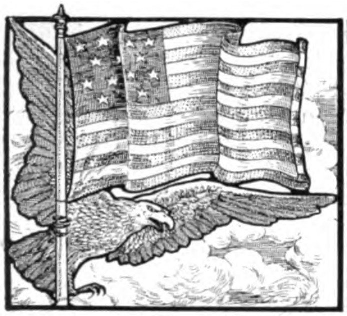


Fig. . Machine for Testing the Action of Frost.
ITALIAN STATE TESTING LABORATORY.



CONCRETE AS DISCUSSED AT THE NATIONAL ASSOCIATION OF CEMENT USERS, U.S.A.

The National Association of Cement Users of America held their sixth Annual Convention at Chicago in February last, when a number of valuable papers and reports were read. The more important of these will be published in our Journal.—ED.

THE USE OF CONCRETE IN FARM BUILDINGS FROM A SANITARY STANDPOINT.

By S. CUNNINGHAM.

THE requirements for sanitary construction of farm buildings make concrete and cement the most useful material for floors and walls and even for roofs and ceilings when expense does not prohibit its use.

Most Boards of Health which undertake to regulate the production of milk sold under their jurisdiction require or advise the use of cement for floors in cow stables and specify also that the walls and ceilings must be tight, clean, and free from dust-catching surfaces, which evidently suggest the use of cement or hard plaster finishes. At present, stables are usually built of wood, but concrete in blocks or cast in forms is being used more each year, and there are already a large number of barns scattered throughout the country which show in a highly developed way the best uses of concrete. The fireproof and permanent qualities of this material are also powerful inducements towards its use. The ease with which it may be kept clean, the good health of the animals stabled therein, and the possibility of producing clean milk with a minimum of labour—all increase the weight of argument in its behalf.

Floors.—For floors, concrete shows practically no wear from use; it is watertight, non-absorbent and sanitary, and if sufficient bedding is used it makes a satisfactory material for animals to stand and lie upon. When the floor is upon earth fill, it is advisable to put a layer of sand 6 in. or more thick under it, especially in damp localities, and to place under the stalls themselves a waterproofing layer which is easily made by putting down two or three layers of tar-paper on a base of cement, and brushing it well with coal tar pitch. This prevents dampness from drawing up through the concrete and makes a warmer floor. The waterproofing should be covered with a thickness of concrete and cement surfacing of at least 3 in. for cow stalls and 4 in. for horse stalls. It is possible to use less than this for cow stalls (but not advisable in horse stalls) by putting down metal lath over the waterproofing, nailing through to the concrete beneath to hold the lath firm, then plastering the lath with a heavy coat of cement mortar mixed 1 to 2, 1-in. thick, or more. All stall surfaces and passages to be used by animals should be left rough, finished with a wooden float, or a float covered with carpet.

The feed mangers in front of the cow stalls should be low and of just sufficient depth to allow also of watering the cows. Six inches is deep enough. Watering in this way at regular periods has been proved the best for cows. They drink more, and at more suitable intervals, than when they have water always before them in individual drinking pots, which are, besides, very difficult to keep clean.

The stalls should be made fairly short and should pitch not more than 1 in. to 1½ in. to the gutter. All feed passages, mangers and gutters should have a smooth hard trowelled finish, which is easier to keep clean than a float finish. Horse stall floors should be treated as for cow stalls. They should pitch about 2 in. toward the gutter. The gutter in this case should be very shallow, not over 1½ in. deep, 16 in. wide, and uncovered. There will be more wear on horse stall floors, so they should be laid more carefully with this in view.

Where the floors join the walls, and, in fact, all interior angles in the stable, should be covered or rounded on a 3-in. radius to prevent corners for the collection of dirt—a small detail, but one that makes a great difference in the cleanliness of a stable.

Walls.—Concrete in many forms has been used for walls. The object to be attained is a hard, smooth wall surface insulated as well as possible from changes of external temperature. It is, of course, not difficult to prevent moisture coming through from the outside, but condensation of moisture inside is more difficult to avoid. Concrete blocks with air spaces, cored, reinforced walls, and solid walls, furred with wood or metal and finished with plaster on metal lath, or lined with plastered partition tile or concrete blocks with a space between the two walls, are methods used for insulation. Dampness in a stable is very often a sign of poor ventilation. If the air space in the walls is filled with chopped straw, sawdust, or planer chips, the insulation is improved.

Ventilation.—This subject of ventilation is very important, and definite means should be provided to ensure a proper circulation of air. The old farm buildings, which were scarcely more than rough sheds, were full of cracks through which the air could pass. Modern concrete barns leave no such chances for haphazard ventilation, and with forty cows in a barn of 20,000 cu. ft. capacity, each cow requiring five or six times the amount of air necessary for a man, the ventilation must be positive and adequate to make the conditions healthful. There are several good systems of natural ventilation, and no barn should be constructed without one of these, or other proper means to supply fresh air. In northern climates the barns should be made small, about 500 or 600 cu. ft. capacity per animal is about right. Such a building is easier to keep warm, and yet is large enough to allow of proper ventilation without causing severe draughts. The ventilating flues may be built of concrete, tall enough to act on the principle of a chimney, and to cause circulation by difference in weight of the column of warm air within and cold air outside.

For piggeries, the use of cement in construction is as advisable as for stables. They are much more likely to be neglected and allowed to become foul, and a cement finish is so easily washed down that there is no excuse for any such condition. Pigs are liable to contagious diseases, and a building that can be hosed out and disinfected, and having no absorbent materials or cracks to harbour bacteria, can be used again with no danger of the infection spreading. This applies as well to cow stables.

Silos.—Almost all large milk farms depend in a great degree on ensilage for feed. A cement silo is equal to the best that can be built for storing ensilage. The proper preservation of ensilage depends on keeping it packed tight to exclude the air, with smooth walls, so that as the ensilage settles it does not loosen at the walls to admit air there. Structurally, cement silos are practically everlasting. The acids existing in the fermented juice of the corn attack the surface to a very slight degree only, and cement walls, either solid or cored, prevent the freezing of ensilage better than a wooden stave silo the form most commonly used. The freezing not only spoils that part of the ensilage lying within a few inches of the wall, but by causing the frozen ensilage to cling to the wall, the even settlement is interfered with and part of the rest spoiled by the admission of air.

Poultry Houses.—For poultry houses, concrete makes a warm, tight building that will exclude rats and other animals preying on chickens, and that can be kept clean to the prevention of vermin. The floors in laying-house pens should be made 6 in. below the levels of the door sills and filled with cut straw or gravel for scratching. This can be renewed as often as necessary to keep them clean.

Where manure is stored and not spread on the fields as soon as produced, a tight pit, covered or uncovered, is necessary, and concrete offers an excellent material of which to construct such pits. The floors may be pitched to a sump pit in one corner and the liquid pumped out and applied to the fields, using a sprinkling cast for this purpose.

The production of clean milk requires the best sanitary conditions in the buildings in which the milk is handled, as well as in the cow stable where it is produced. The extensive use of concrete floors and smooth plastered walls with coves in all angles will make such a dairy easy to keep clean, but offers no particular requirements in the way of sanitary design.

For greenhouses, hot-beds, and wherever wood in contact with earth has been found to rot out, concrete has been substituted with the expected advantages. Tables in greenhouses can be easily designed and built of it, making them permanent and avoiding a large item of expense in renewals. No objection has been discovered to its use in this way from any unfavourable action on the plant life. In fact, it forms a better protection than wood from possible variations of temperature.

The fact that concrete can be kept clean more easily than any other material in common use is its greatest recommendation for its use in farm buildings. The realisation that health to a very great degree depends on cleanliness is as true for farm stock as it is for mankind. Good labouring help is difficult to obtain on most farms, and anything that contributes to the reduction of labour necessary to keep the surroundings clean is bound to grow rapidly in favour on that score alone, especially since no valid objections can be substantiated to its use in connection with stock or farm products.

LAYING CONCRETE UNDER WATER.

DETROIT RIVER TUNNEL.

By OLAF HOFF. Consulting Engineer, New York.

VARIOUS expedients and devices have been adopted for solving the problem of depositing concrete under water, the principal ones being the use of bags, drop-bottom buckets and tremies, all subject to objections peculiar to each.

Various Methods of Laying Concrete under Water.—Laying concrete under water by means of bags involves the use of divers in placing the bags, and is, accordingly, cumbersome, slow, and expensive; the results are not wholly satisfactory and the method should be classed as obsolete.

Neither is the use of drop-bottom buckets all that could be desired; even with the greatest care it is not possible to prevent the mass from dropping a short distance through the water, which, thus set in motion, has a tendency to remove the cement from the aggregate and produce a lean concrete in spots, where a uniform and homogeneous structure is the ideal sought for. Irregular cleavage lines in the concrete are likely to occur, which objection is also applicable to the use of bags.

The depositing of concrete in water by means of tremies has heretofore presented difficulties which have not always produced satisfactory results. A tremie is nothing more or less than a long tube reaching from the place where the concrete is to be deposited to the surface of the water above, its upper end being provided with a hopper for receiving the mixture; as fast as the concrete escapes at the lower end of the tube it is replenished at the upper end, thus flowing in a continuous stream.

Theoretically, this is the ideal way of laying concrete under water, but when reduced to practice the object has not proved so easy of accomplishment. The difficulty has principally been to control the flow of the concrete through the tube and prevent the water from the outside rushing into the tube from below, thus washing the concrete and separating the cement from the aggregate, losing the charge; the concrete would be liable to run out either too fast or too slow. Generally the concrete has been deposited in layers of various thicknesses, governed by the position of the mouth of the tremie with reference to that of the layers below. This also, of necessity, results in a certain amount of motion of the concrete through the water, with attending loss of cement.

These difficulties were successfully overcome in the construction of the Detroit River Tunnel, more than one hundred thousand cubic yards of concrete having been deposited in water by means of tremies, the operation extending over a period of part of three seasons, 1907, 1908, and 1909.

In order to describe the methods used and convey a correct understanding of same, it will first be necessary to give a short description of the tunnel itself and more particularly the subaqueous part of same.

Detroit River Tunnel.—This tunnel is of double track, built for the use of the New York Central system of railroad lines, passing under the Detroit River and connecting the city of Detroit, Mich., with the town of Windsor, Canada. It is built as two separate tubes with a centre wall between each with an overhead clearance of 18 ft. above top of rail, and a length of 8,360 ft. from portal to portal. It consists of three sections, the westerly approach on the American side, 2,135 ft. long, the section under the Detroit River proper, or subaqueous section, 2,625 ft. long, and the easterly approach tunnel on the Canadian side, 3,600 ft. long.

The westerly approach tunnel and adjoining end of the subaqueous section is on a 2 per cent. gradient and the easterly approach tunnel on a 1½ per cent. gradient. The subaqueous section has a level grade of some 1,000 ft. merging into the approaching gradients through long vertical curves at either end. It also has a short horizontal curve of two degrees curvature at the westerly end. The portals are approached through long open cuts at both ends of the tunnel.

The approach tunnels on both sides of the river were driven through a formation of plastic blue clay by means of shields. The same clay formation extends across the river and overlies bed rock which is found at a depth of some 10 ft. to 30 ft. below the tunnel structure.

The subaqueous section was built on a unique and novel plan never heretofore used, which proved highly successful both as to cost, speed of construction and safety. It consisted in excavating a trench in the bottom of the river, of the required width and depth, into which steel tubes were sunk; these were thereupon encased in concrete laid under water, pumped out and then lined with concrete on the inside. The whole operation proved to be very simple and easy of execution.

The top of the tunnel structure generally follows the bottom of the river; at the middle it even projects a few feet above the bottom; at the deepest part it is 41 ft. 9 in. below the surface. The bottom of the structure at this point is about 74 ft. below the surface of the river.

The excavation of the trench was done with an ordinary clam shell dredge, well in advance of the sinking of the tubes. The tubes were circular in form, with a diameter of 23 ft. 4 in., and were arranged and sunk in pairs, one tube for each track; they were built of ⅜-in. steel plates. They were spaced 3 ft. apart between the shells and reinforced on the outside by a series of transverse steel partitions or diaphragms, 12 ft. apart. These diaphragms extended all around the tubes and were approximately of rectangular shape with an extreme depth of 30 ft. 4 in. and extreme width of 55 ft. 8 in.; thus extending beyond the steel shell 3 ft. at the bottom, 3 ft. on the sides, and 4 ft. on the top of the tubes. They were strengthened by means of double angle irons riveted along the edges; wooden sheathing running lengthwise of the tubes was bolted along the vertical edges of the diaphragms. The tubes were built in lengths of 262 ft. 6 in. and were provided with temporary wooden bulk-heads at the ends so that they would float when launched.

For the purpose of sinking the tubes they were equipped with four buoyancy cylinders attached on top, which enabled the tubes, when filled with water, to be kept in suspension at any point, lowered to the final resting place by means of floating derricks and connected up with the tubes already sunk.

Before sinking, a platform was built in the bottom of the trench at the proper level to temporarily support the ends of the tubes. When in their final position the tubes underneath would be from 5 ft. to 7 ft. from the bottom of the trench depending upon how near the correct level this was excavated. The diaphragms crosswise of the tubes, and the wooden sheathing on the sides parallel with the tubes, would then present in exterior view a series of pockets open at the top and bottom, but with enclosed sides and ends. Into these pockets concrete was poured by means of three tremies, one placed in the middle between the two tubes and one on the outside of each tube, between the steel shell and the wooden sheathing.

Method of Placing the Concrete.—The mode of procedure in placing the concrete was generally, first to concrete in the bottom to the under side of the diaphragm, thus sealing the pockets and affording support for the tubes. The buoyancy cylinders holding the tubes in suspension could then be removed, and each pocket filled with concrete in one continuous operation, forming a monolithic mass of a thickness of 3 ft. on the sides of and between the tubes, 4 ft. to 4 ft. 6 in. on top of the tubes, and a thickness of 5 ft. to 7 ft. underneath the tubes, varying with the irregularity of the bottom.

Generally, every other tube length was-provided with an extra strong bulkhead at the extreme end, capable of resisting the full hydrostatic pressure when the tubes were pumped out, in order to give access to the interior and permit the placing of the concrete lining.

The equipment used for the purpose of placing the subaqueous concrete consisted of a "tremie scow," so-called, especially designed and built for the purpose. This scow was 35 ft. in width, 153 ft. in length, and 9 ft. 9 in. in depth, with a freeboard of about 4 ft. It was equipped with four spuds, one in each corner, of 20 in. square 90 ft. long Oregon fir timbers, and necessary spud hoists. The object of these spuds was to hold the scow steady during concreting, and prevent any rocking motions caused by waves, or the wash from passing steamers. The scow was further held in position against the current by anchors and was equipped with deck hoists for handling. On one side of the scow were built three towers, 82 ft. high above the deck, one for each tremie; the front of these towers served the purpose of leaders (similar to those of a pile driver) for the tremie pipes, which could be hoisted clear out of the water or lowered down to the bottom of the trench, as required. There were three concrete mixers, one for the middle tremie with a capacity of about 30 cu. ft. to the batch, and two concrete mixers, one for each of the side tremies with a capacity of about 20 cu. ft. to the batch. The equipment further consisted of an air compressor, a dynamo and an electric conveyor for conveying cement to the charging floor from scows alongside the tremie scow, three hoisting engines for the tremies, two large derricks with hoisting engines for unloading gravel, and a 150 h.p. boiler.

Gravel was used for mixing the concrete in preference to broken stone; it was of size grading from that of small walnuts downwards. The tremie scow was designed particularly for the purpose of handling and mixing this gravel as cheaply as possible. The gravel was unloaded directly from the boats to the tremie scow and used up about as fast as unloaded. To this end the tremie scow was equipped with two heavy derricks located about at the quarter points of the scow on the opposite side to that of the tremie tower. There was one sand bin and one gravel bin for each tremie. The bins for the centre tremie were of about twice the capacity of the others, because this tremie had to deposit approximately twice as much concrete. The screens below the unloading hoppers were four in number, two for each hopper, inclined in opposite directions so that the gravel would feed one-half to the bin of the side tremie and one-half to that of the centre tremie. The sand and gravel bins were placed a few feet above the charging floor, which was located 11 ft. above the deck of the scow, and was on a level with the top of the charging hopper of the concrete mixers. Through gates in the bottom of the bins the proper amount of gravel and sand could be drawn into the charging hoppers. This floor was large enough to hold a sufficient quantity of cement for one pocket. The water tank was also located on this floor, from which water was piped to the mixers.

The concrete mixers were placed directly on the deck and when tilted would discharge into self-dumping buckets, placed in the hull of the scow directly in front of the mixers; these buckets could be hoisted up to any point where the receiving hoppers of the tremies might happen to be located and discharge their contents into same.

The total amount of concrete in one pocket was about 342 cu. yds., of which approximately one-half had to be deposited through the centre tremie and one-fourth through each of the side tremies.

Each tremie consisted of a 12-in. diameter spiral riveted steel pipe of No. 10 metal, 80 ft. long, made in 20 ft. lengths provided with external flanges for bolting up. The upper end of the tremie pipe was suspended from a frame, to which was attached a hopper for charging the tremie, the hoppers with frames running between guides attached to the front of the before-mentioned towers. The tremie pipes, hoppers and all could be raised and lowered by means of steel hoisting ropes leading over sheaves at the top of the scow. The buckets in the hold of the scow, upon receiving a charge from the concrete mixers, were hoisted up inside the towers until they reached the tremie hoppers, which would engage them and trip them forward, discharging their contents into the hoppers; then they would reverse and go down to their place in the hold of the scow. These buckets ran between guides located inside the towers immediately in the rear of the guides of the tremie hoppers. The concrete, in passing from a mixer into the bucket, would discharge over an apron which the bucket would trip forward every time it descended and trip back out of the way when hoisted up. The tremie hoppers were provided with a small platform on the outside and a railing around same where a man could stand and watch the concrete in the tremie, whether it was running out too fast or too slow, and give signals accordingly to the engineer who ran the corresponding engine.

The working force for operating the tremie scow when the process of concreting was going on was 32 men on an average.

Method of Working the Tremie Scow.—The tremie scow was anchored across the tunnel tubes in the trench so that the tremies when lowered into place would come in the middle of the pocket, as already stated, one tremie between the tubes and one on the outside of each tube between the steel shell and the sheathing. The spuds were then lowered to the bottom and forced down sufficiently to take up a considerable load from the scow and prevent any rocking motions. The three tremie pipes were lowered into position until their lower ends rested on the bottom of the trench; the water inside of the tremie tubes would, of course, be at the same level with the water outside. Meanwhile, the boat loaded with gravel would be placed alongside the tremie scow on the opposite side. The gravel with its mixture of sand would then be unloaded by means of the clam shells and derricks, and dropped into the hoppers previously described, falling over the inclined screens, the sand and gravel shooting off into their respective bins, from which they would, in turn, be drawn as required into the super hoppers of the concrete mixers, cement added, and the charge shot into the mixers, where the necessary water was added in the usual way.

A wadding of cement sacks was at first placed in each tremie on top of the water to prevent the concrete from dropping through while filling the pipe. A batch of concrete was discharged from the mixer into the bucket in the hold of the scow and hoisted up until a projecting arm on the receiving hopper of the tremie would cause the bucket to tilt forward and discharge the contents into the tremie hopper and on top of the wadding, the bucket immediately returning to its original place to receive a new charge, already in the process of mixing. When this hopper was about half filled, the tremie and hopper would be raised a trifle, permitting the water in the tremie to escape at the bottom as the weight of the concrete pushed the wadding downwards through the pipe. Meanwhile fresh batches of concrete were being dumped into the tremie hoppers. In this manner the tremie was filled with concrete until the wadding reached the bottom and the concrete commenced to run out of the pipes. As fast as the concrete ran out at the lower end of the tremie pipe, fresh concrete would be added to the upper end of same, this process going on until the whole pocket was filled.

This wadding of cement bags was used only at the beginning of the work. It was soon found that one or two very dry batches of concrete would serve the same purpose, and this was used practically throughout the work in charging the tremie at the beginning of an operation.

The concrete, except as noted in charging the tremies, was mixed very wet, much more so than would be permissible in concrete deposited in the air. No difficulty, however, was experienced on this account.

It should be particularly noted that the mouth of the tremie was always buried in the concrete from 2 ft. to 5 ft., forming an effective seal which at all times prevented the outside water from forcing itself into the tremie. It was the duty of the inspector on the platform of the tremie hopper to always be on the look-out that the tremie was full of concrete. If the concrete showed a tendency to run out too fast he would signal the hoisting engineer to lower the tremie and thus choke off the flow; if the concrete did not flow fast enough he would order the tremie raised until the concrete would flow more rapidly.

In depositing the concrete divers were employed for inspecting the progress of the work, and report when a pocket was completed.

The time required for filling one pocket usually ran from 4 to 7 hours. The largest amount of concrete placed by the tremie scow per day was three pockets or 1,025 cu. yds., working 16 hours. This includes the time required for replacing the gravel boats alongside the tremie scow.

The length of time of mixing a batch was usually from 2 to 3 minutes. The time for the concrete to reach its place of deposit from the mixer would, of course, vary greatly, but the average time was probably about 8 minutes, with a minimum of 5 minutes and a maximum of 15. The velocity of the flow of concrete in the tremies would average from 14 ft. to 15 ft. per minute, the extremes probably running from 7 ft. to 25 ft.

When the work first commenced the side tremies were made of 10-in. pipe, as against 12-in. for the centre tremie. This was done because the amount of concrete passing through each of the side tremies was approximately only half of that of the centre tremie. After the first section had been completed all three tremies were made 12 in. in diameter for the sake of convenience, as by that time it was found that the flow of the concrete could be absolutely regulated to suit the requirements.

The wear and tear of the tremie pipes proved very insignificant, the full set of tremies having been renewed only once.

Mixture of the Concrete.—The concrete was mixed in the following proportions: In the bottom of the trench below the diaphragms it consisted of 1 part of cement to 4 parts of sand and 8 parts of gravel. The concrete in the pockets consisted of 1 part of cement to 3 parts of sand and 6 parts of gravel. Gravel of small walnut size was used in preference to crushed stone as it was thought it would cause the concrete to flow easier in the tremies; besides gravel makes a denser concrete than crushed stone.

In some of the pockets at the joints between two sections the concrete was made in the proportion of 1 part of cement to 2 of sand and 4 of gravel. The reason for making the concrete in these pockets richer was simply a matter of precaution, taken to insure a tight joint, the steel work not fitting together as closely as intended. When the tubes were pumped out no water came through these joints, showing that the 1 : 2 : 4 concrete was practically impervious to water, although subject to a hydrostatic pressure of about 25 lb. to the sq. in.

For the purpose of determining the quality of the concrete, 6-in. cores were taken out by means of a Davis Calyx drill for the full height of the centre wall between the steel tubes. These cores show a remarkable degree of uniformity of the concrete and of high quality both as to density and strength; in fact, a better grade of concrete was obtained than would be possible in the open air. It should be noted in this connection that this concrete was compressed and set up under a hydrostatic pressure of from 16 lb. to 30 lb. per sq. in., at the top and the bottom of a pocket respectively.

The crushing strength of this concrete, when 1 year old, ran from about 2,800 lb. per sq. in. minimum, to 4,000 lb. per sq. in. maximum, for a mixture 1 : 3 : 6 according to tests made upon cores taken from the centre wall.

Setting Time.— A word should be said with respect to the time of setting or hardening of the concrete; that is, to be sure, a debatable subject. However, the consensus of opinion among the engineers connected with the work, including the writer, based upon such tests as could be made by divers, seemed to be that the initial set was acquired in about 10 hours after the concrete was deposited, and the final set in 20 hours; after 40 hours the concrete was very hard, so that it would ring when struck with an iron bar.

Regarding the matter of laitance, hardly any was observed that would affect the quality of the work; this might be expected considering the manner in which this concrete was deposited, whereby the great mass of it would never come in contact with the water at all.

It may not be amiss to point out the three essential elements that contributed to the successful results in depositing the subaqueous concrete of the Detroit River Tunnel; they are as follows:

First, dividing the exterior of the tunnel tubes, by means of the longitudinal sheathing and the diaphragms, into compartments or pockets. This produced still water, which is absolutely essential for laying concrete under water, and permitted the filling of one pocket at a time with one monolithic mass of concrete. This arrangement further limited the lateral flow of the concrete, as it emerged from the tremie, to the confine of the pocket and reduced the washing out of cement by the water to an absolute minimum, in fact the loss of cement appeared to be negligible.

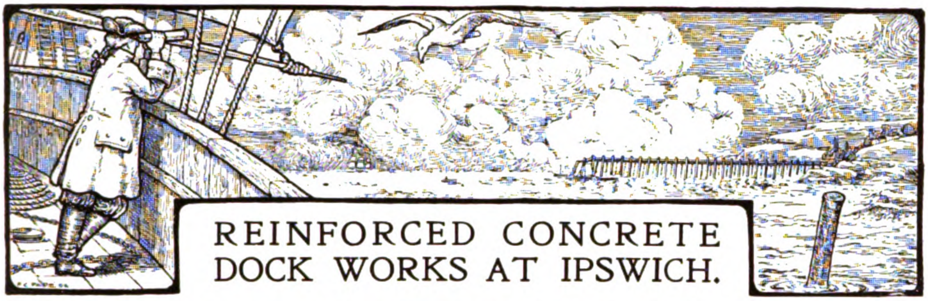
Second, the use of an equipment complete in every detail and equal to any demand made upon it, more especially an active or quick-acting rig for handling the tremie pipes promptly as occasion required.

Third, mixing the concrete so wet that it would readily flow in the tremies, and the flow controlled by keeping the mouth of the tremie at all times buried in the concrete at a sufficient depth thereby at the same time keeping it sealed and preventing the water from rushing in from the outside.

The demonstration of these highly successful results on such a large scale suggests possibilities of the application of this method to various kinds of engineering works, other than subaqueous tunnels. It may perhaps be permissible to venture a few suggestions of such applications.

Structures now frequently built of cyclopean concrete blocks, such as dock and quay walls, breakwaters, etc., could in many instances be built *in situ*, by using steel forms constructed on the compartment or pocket principle, which would result in obtaining monolithic and massive blocks, or sections of structure of far greater magnitude, than otherwise possible. The steel forms could be built extremely light and left in place, or heavier and detachable to permit their being used over again, as economy and expediency might dictate. If piles were required for providing a proper foundation they could be driven after the excavation was done to the required level, the forms set over them and then embedding them in concrete.

Similarly, dry docks, lighthouse foundations and bridge piers could be constructed, always, of course, depending upon local conditions and circumstances as to the applicability of the method.



REINFORCED CONCRETE DOCK WORKS AT IPSWICH.

The following account of the improvement at the Ipswich Docks should be of interest to our readers, giving as it does particulars of the reinforced concrete quay. We hope at a later date to be able to show views of the finished structure.—ED.

A NOTABLE improvement now in progress for the Ipswich Dock Commissioners includes the reconstruction of the narrow quay in front of the public warehouse and an extension bringing the total length of the new quay up to about 325 ft. long from end to end.

The original works, constructed in 1880, provided merely a timber quay, 11 ft. wide by 170 ft. long, in front of the warehouse, and as the natural slope of the dock bottom could not be interfered with for fear of impairing the foundations of both structures, the depth alongside was only 8 ft. 6 in., making it impossible for vessels to discharge cargo directly upon the quay.

In addition to the necessity of bringing the deep water of the dock nearer to the warehouse, the dilapidated condition of the timber framed wharf rendered the work of reconstruction unavoidable.

The scheme prepared by Mr. Thomas Miller, M.Inst.C.E., the engineer to the Dock Commissioners, provides for a reinforced concrete deepwater quay

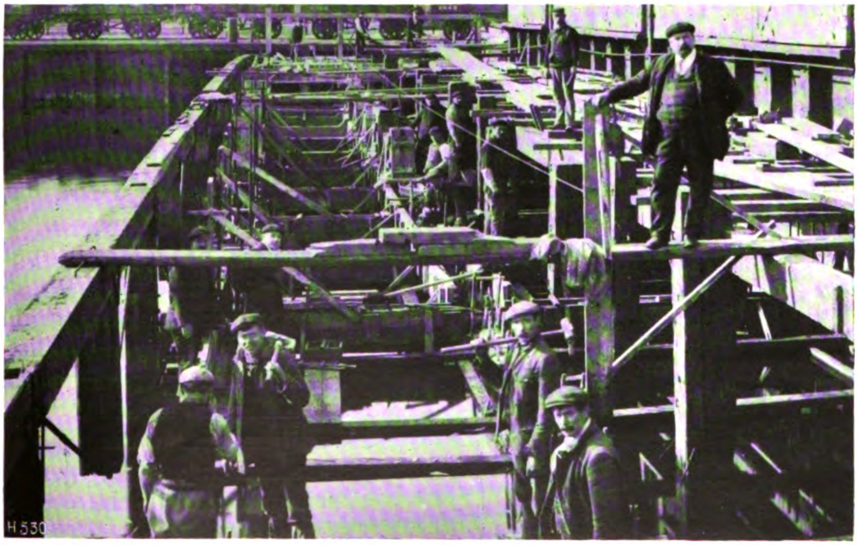


Fig. 1. Quay in course of construction.
REINFORCED CONCRETE DOCK WORKS AT IPSWICH.

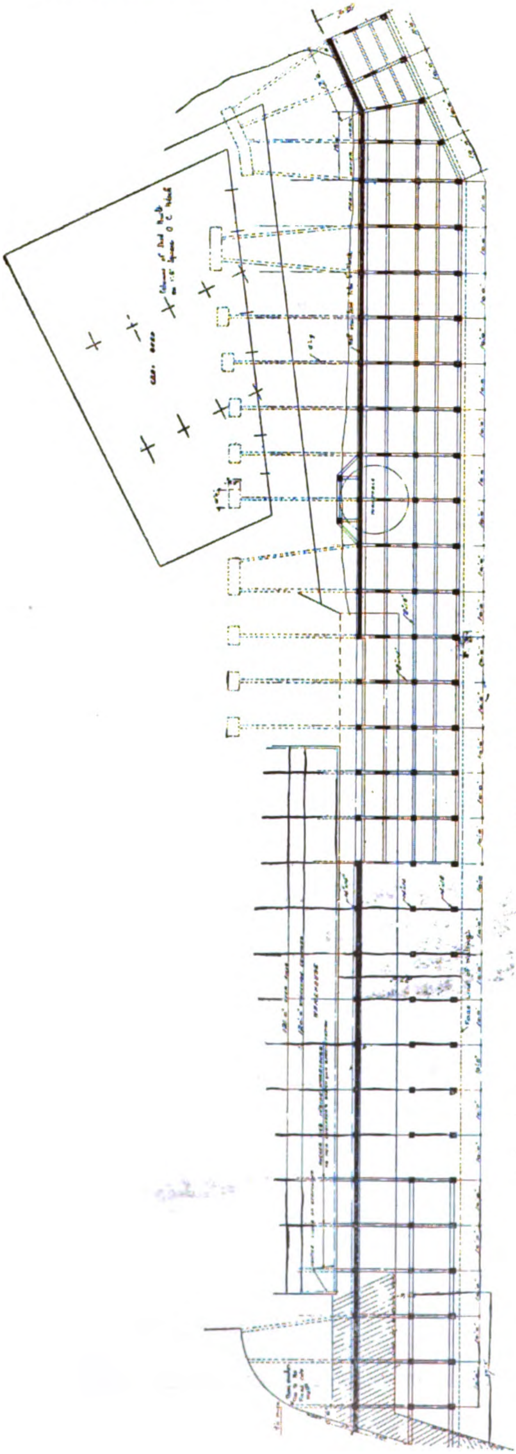


Fig. 2. Plan of new quay.

REINFORCED CONCRETE DOCK WORKS AT IPSWICH.

27 ft. wide throughout, with accommodation for one railway track connected in two directions with existing lines of rails from the New Cut East and the New South - East deepwater quay. Thus the dock authorities will secure safe berths for the long and deep draught vessels frequenting the port, as well as means of dealing more expeditiously with cargo, and will have excellent means of transport to and from the public warehouse and other buildings behind the quay.

After the consideration of tenders under various forms of reinforced concrete, the Commissioners accepted one in accordance with the Hennebique system of reinforced concrete, submitted by Messrs. A. Jackaman & Son, of Slough, by whom the recent extension of Parkeston Quay was carried out for the Great Eastern Railway Company.

Fig. 2 is a general plan showing the extent and main dimensions of the new quay and the positions of the public warehouse and coal storage shed. Besides the construction of the quay, the works include some interesting examples of underpinning and anchorage, the latter being for the purpose of enabling the new structure to withstand the outward pressure of earth and filling employed for reclamation purposes. Another detail of special interest is the turntable pit, near one end of the coal storage shed.

By the general plan it may

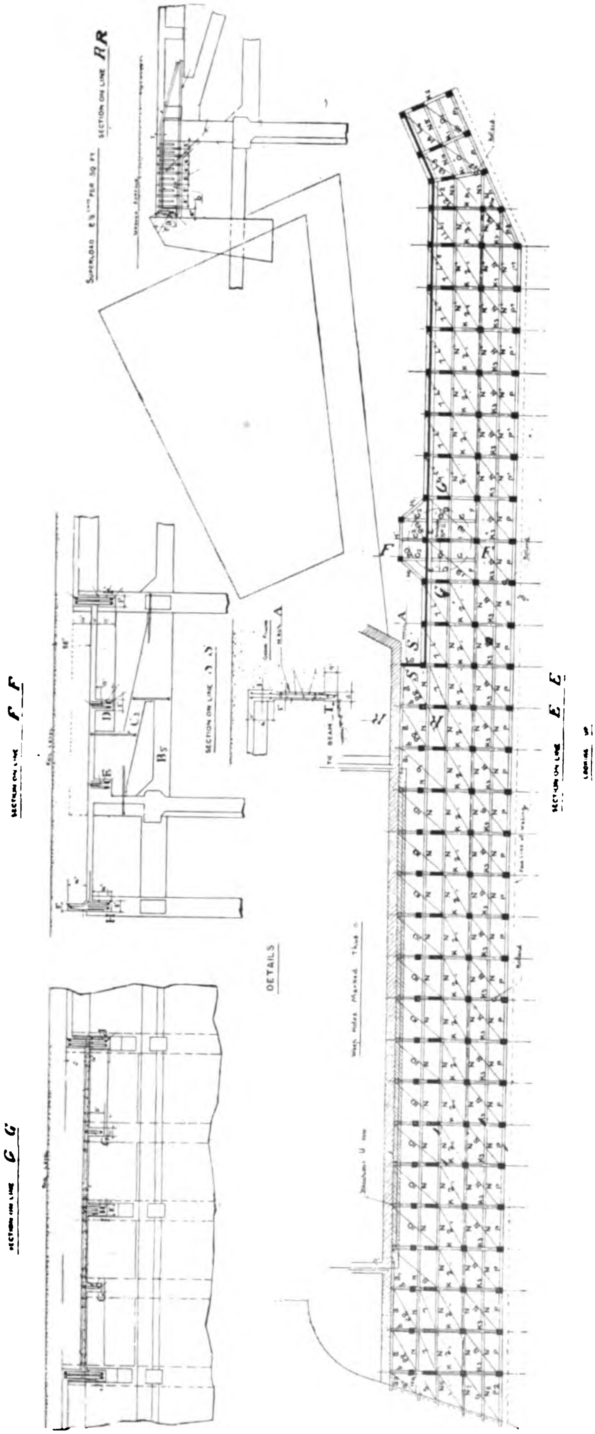


Fig 3. Section of turntable pit.

Reinforced Concrete Dock Works at Ipswich.

be seen that the quay comprises 32 bays founded upon reinforced concrete piles spaced 10 ft. apart longitudinally, except at the further end where the distance is 10½ ft., and at the old lock end where the decking beams are housed into and supported by a masonry wing wall 3 ft. thick.

A more complete idea of the design is furnished by *Fig.* 4, which gives a section in front of the warehouse. The foundation piles in the front row are 14 in. by 18 in., and those in the back and intermediate rows 14 in. square, driven into the gravel slope of the dock to the depth necessary for stability and for resistance equal to the load of 30 tons, due to the rolling load of a 27-ton shunting engine and the distributed superload of 2½ cwt. per sq. ft. on the decking.

Between the foundation piles of the middle row sheet piles are driven and keyed up with cement grout, thus forming a continuous diaphragm from end to end of the wharf, serving the purpose of a retaining wall for filling deposited

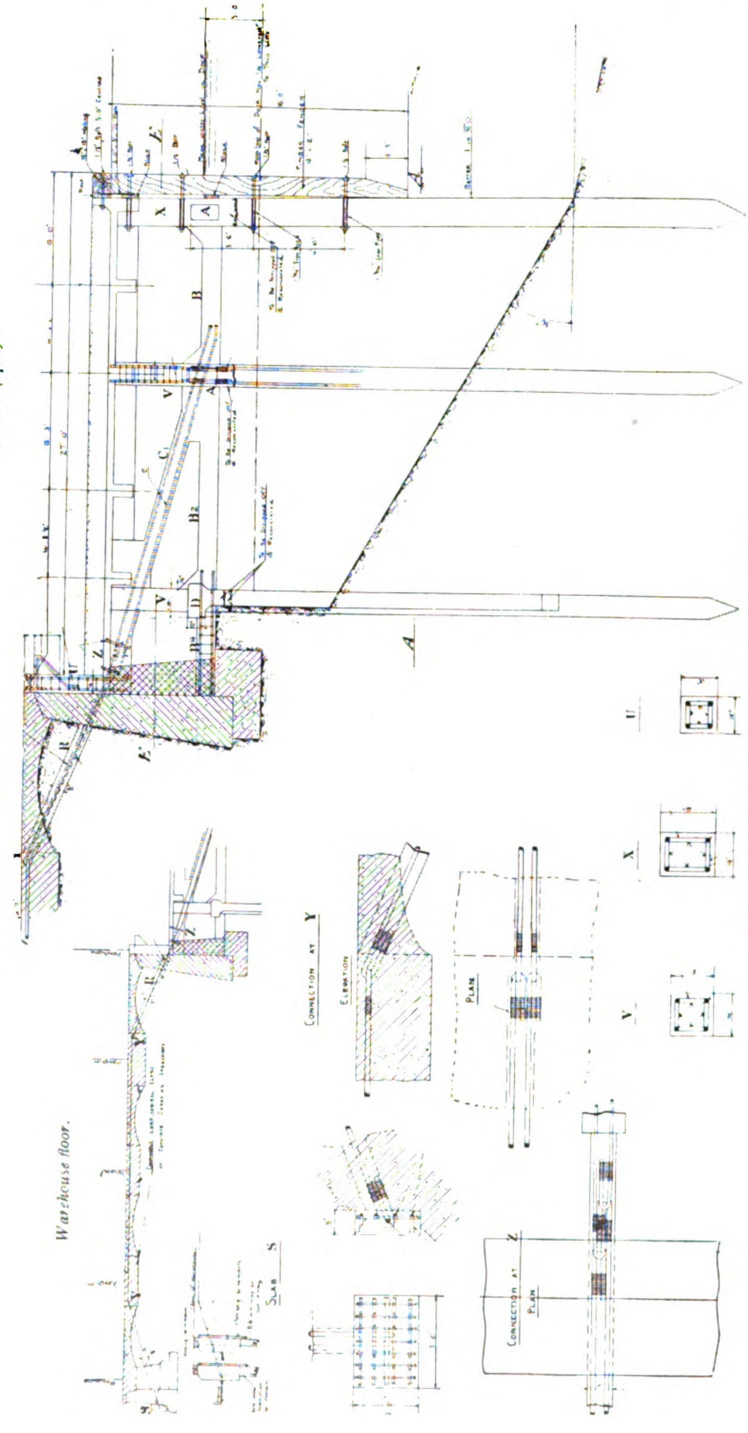


Fig. 4. Section of quay, warehouse floor and details.
REINFORCED CONCRETE DOCK WORKS AT IPSWICH.

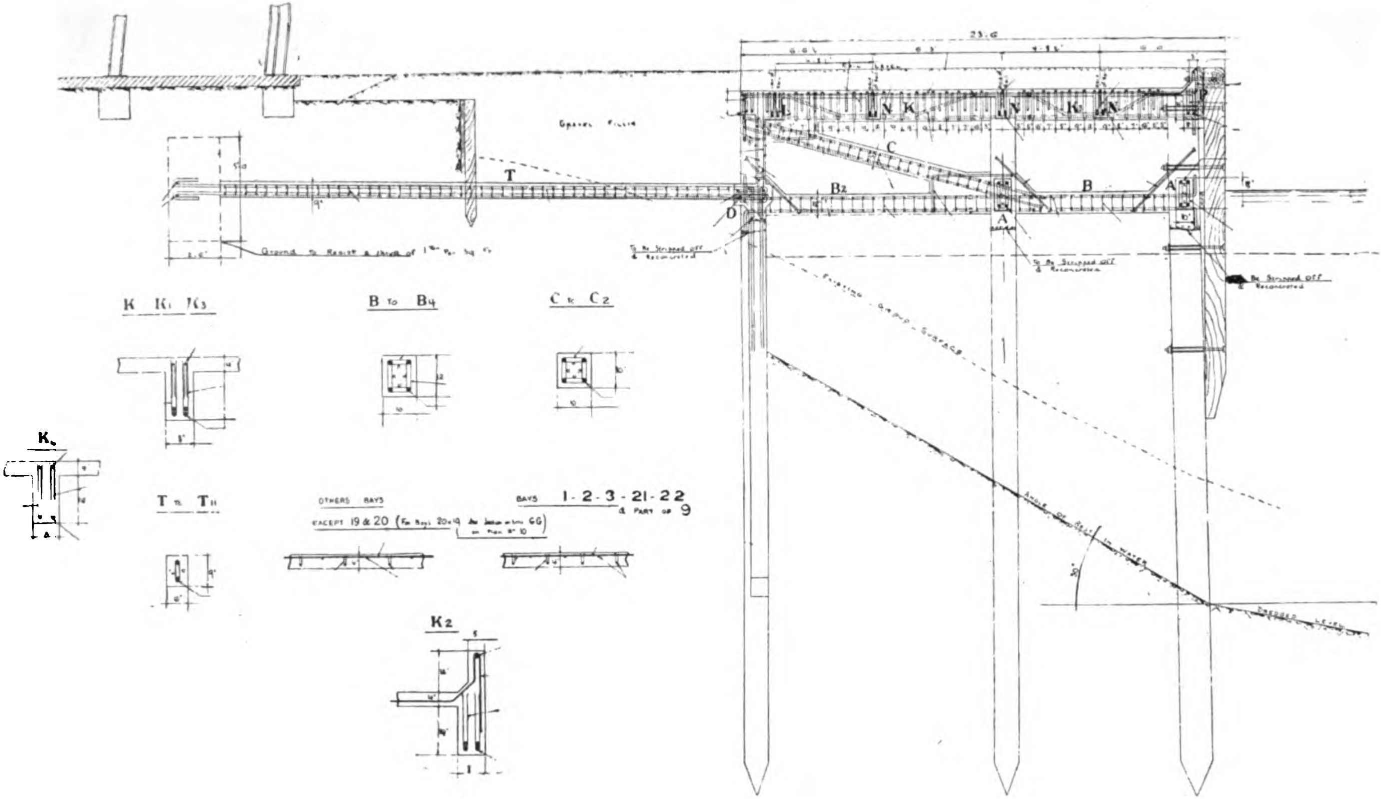
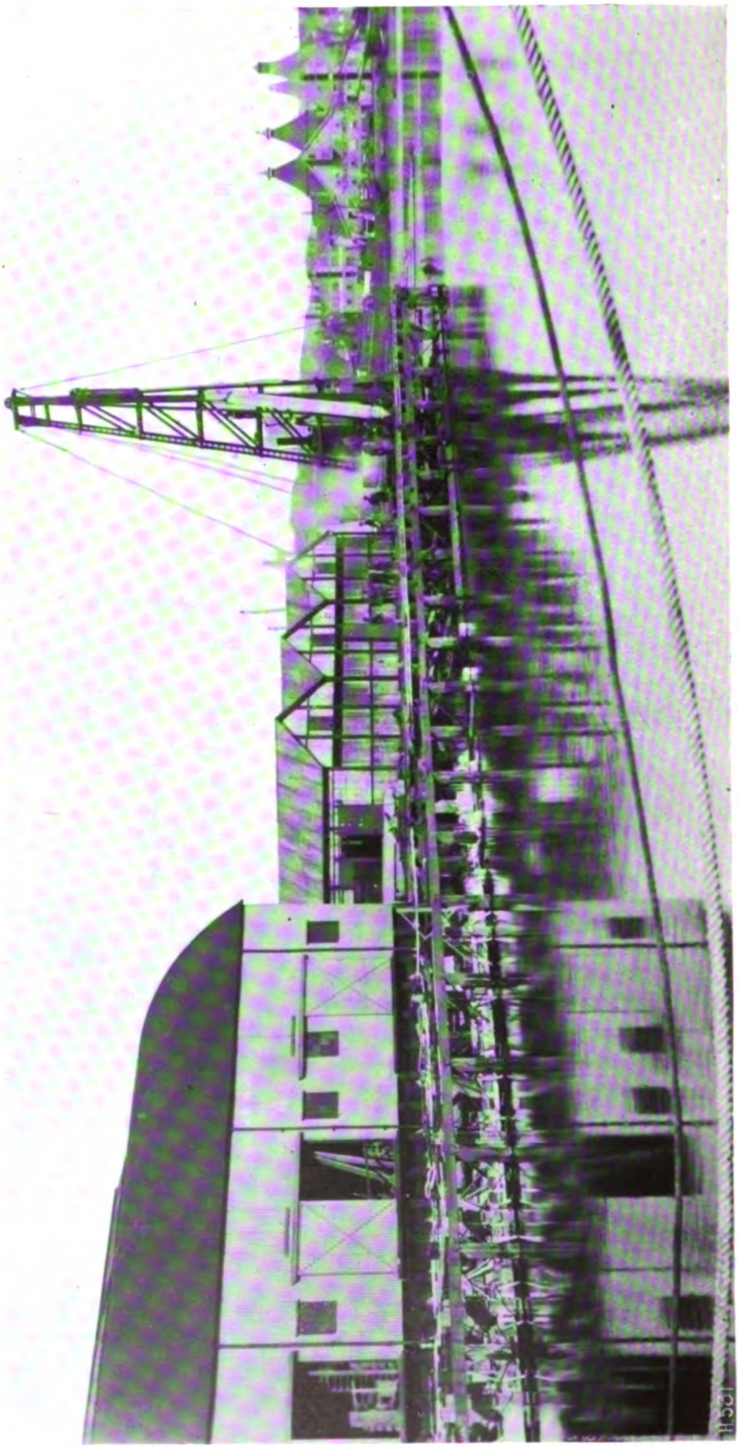


Fig. 5. Section in front of coal shed, showing land ties under same.
Reinforced Concrete Dock Works at Ipswich.



View in course of construction.
Reinforced Concrete Dock Works at Ipswich.

on the landward side, and making impossible any penetration of water from the dock.

The main piles are continued upward in the form of columns securely braced by longitudinal wallings and transverse members which, together with the deck beams, constitute a series of rigid frames, all in monolithic connection, and further stiffened by the continuous slab joining up the longitudinal and transverse beams.

The decking projects 5 ft. beyond the back row of piles, this portion being capable of acting as a cantilever, although supported in front of the warehouse by the concrete foundation wall shown in the section. Elsewhere the projection is supported entirely by the cantilevers. Thanks to the depth to which the main piles are driven into the gravel, the rigidity of the framed structure, and the securely anchored ties before mentioned, the new quay has enabled the dock engineer to provide for dredging away material to the depth of about 6 ft., so as to give about 21 ft. of water alongside.

The first and most important operation for attention by the contractors was that of underpinning the front wall of the public warehouse, with the frontage of 121 ft. to the dock. In performing this work the whole of the timber platform, beams, wallings, and other parts of the old wharf had to be removed, part at a time, so as to give access to the warehouse foundations. These were supported by 12 in. square timber piles spaced 10 ft. apart with 10 in. square intermediate piles also of timber. The 12-in. piles carried the footings of steel stanchions, each bearing the load of 15 tons due to the upper floor and roof of the building, and they were tied back by chains attached to concrete anchor blocks.

The underpinning works included the removal of a timber sill beneath the stanchions, cutting away the decayed upper part of the piles, building a plain concrete wall embedding the sound part of the piles, and carrying up reinforced concrete foundation columns from the top of the wall, just below quay level, to the level of the warehouse floor. A section of the wall and columns may be seen at the left hand of *Fig.* 4, which also shows the main retaining wall and part of the warehouse floor. The reinforced concrete foundation columns are 12 in. square, reinforced by four longitudinal bars with transverse links 6 in. apart, each column being provided with a bracket, as shown, for supporting the grooved rails upon which run the sliding doors along the front of the warehouse.

After the execution of the land ties across the public warehouse had made the supporting piles of the building perfectly safe, the piles close along the front of the warehouse were driven, the vibration from which caused no injury to the warehouse structure. The average length of the piles was about 30 ft., the reinforcement of these members including four longitudinal steel bars braced by transverse links at short intervals apart.

Considerable difficulty was experienced in driving the piles to the required depth through the gravel slope which overlies a compact bed of chalk and clay, forming with variations of level and solidity the bed of the dock, but by continued driving the piles were finally sunk, some of them having received as many as 2,000 blows from a 2-ton monkey. This clearly demonstrated the endurance of the piles and the efficiency of the reinforcement in enabling the concrete to withstand heavy impact, and the consequent bursting strains thereby developed.

By lowering the water level of the dock some 3 ft., the piles were driven with the head projecting about 4 ft. at the distance of about 6 ft. below the future surface of the new quay. The heads were then trimmed off level, and the concrete stripped away to permit the reinforcing bars of the reinforced concrete columns to be lashed to the bars projecting from the piles. This arrangement is illustrated in *Fig.* 4.

The sheet piles driven along the middle line of the quay measure 10 in. thick by 17 in. wide by 20 ft. long, each being moulded with a semi-cylindrical groove at each side forming half of the cylindrical hole, afterwards filled by a key of cement grout. The sheeting was completed by a continuous capping of reinforced concrete 22 in. wide by 12 in. deep, with angle brackets filling the angles at the junction of the capping and piles.

Quay in course of construction.
Reinforced Concrete Dock Works at Ipswich.

The front decking beams are continued up 12 in. above the slab, with the object of providing a curb for the road material, which is paved between the railway metals with wood blocks and the remainder of the surface with macadam.

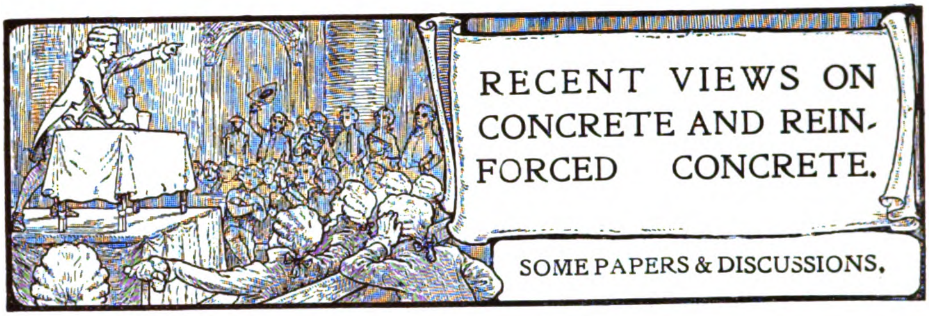
Cast-iron mooring bollards and timber fenders for the protection of ships complete the equipment of the quay front. *Fig.* 4 shows part of one of the reinforced concrete ties, 8 in. square, by which the quay is held back to the land, details of the connections at Z and Y also being given in this illustration. The bars passing through the diagonal braces, C, are bent round 1½ in. diameter pins and bound with steel wire, the reinforcement of the ties consisting of two 1½ in. diameter bars similarly treated.

Fig. 4 also gives a section through the warehouse floor showing a complete set of ties.

Beyond the warehouse the land-tie anchors are laid at a distance of between 30 ft. and 35 ft. from the new front line of the quay, the anchors consisting of concrete blocks buried deep underground. The maximum strain upon each tie is estimated at 18 tons. The anchor blocks measure about 5 ft. by 4 ft. by 2 ft. 6 in., the safe horizontal resistance of the soil being estimated at 1 ton per sq. ft.

Fig. 3 gives longitudinal and transverse sections of the turn-table pit of 15 ft. diameter, carried by the foundation piles of the quay with aid from two extra piles driven behind that structure. This pit demonstrates the capacity of reinforced concrete for the support of heavy machinery without perceptible vibration, a point which, in fact, is also evidenced by the whole of the quay here described.

The details of the reinforced concrete work were prepared by Messrs. L. G. Mouchel & Partners, of 38 Victoria Street, S.W.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE SOCIETY OF ARCHITECTS.

CONSTRUCTIONAL STEELWORK.

By S. BYLANDER.

Mr. S. Bylander delivered a paper on "Constructional Steelwork" before the Society of Architects in April last, at which Mr. Percy B. Tubbs, F.R.I.B.A., presided. The lecture was illustrated by a number of lantern slides and diagrams. The paper is a very interesting one and we are publishing a lengthy summary.

Planning and Designing.—As the sizes of the buildings were increased and fireproof construction adopted, steel construction could be used with advantage. Heavy brick walls were substituted with steel stanchions, and rolled steel beams used instead of wooden joists, thereby saving rentable space, and by the use of fireproof floors the danger of ruinous fire materially reduced. When steelwork constituted the skeleton of the structure, it was obvious that the application of this material should be given careful attention. The architect must, therefore, make himself well acquainted with the principles of steel construction or be in frequent consultation with an engineer competent in steelwork design. Economy was the essential thing to aim at; consistent, of course, with suitable planning and good architecture.

Factor of Safety.—The first consideration the designer had to take into account was the factor of safety and the loads which should be used in the calculations for the different members. If a specification required that the steelwork should be designed for a factor of safety of four, this did not necessarily mean that every member was four times as strong as that required to carry the specified load. Often a structure could not carry more than twice the specified load on account of imperfect loading, material and workmanship, although it was designed for a factor of safety of four. The factor of safety was intended to cover unknown quantities which were not considered in the calculations. Good practice was to use a safe stress for steel equal to one-quarter of the ultimate strength of the material, or seven and a half tons per sq. in., if the ultimate strength of the material was 30 tons per sq. in. As the elastic limit of medium steel was about 15 tons per sq. in., the actual factor of safety would be two.

Loads. — The actual live load was not used in the calculations, but the corresponding dead load which would cause the same stress in the steel as the actual live load. This dead load was usually referred to as "superimposed load," and varied from 70 lb. to 120 lb. per sq. ft. for apartment houses, hotels, and office buildings, and from 150 lb. to 400 lb. per sq. ft. for warehouses and factories. To the above loads should be added the weight of the floor itself (including steel girders and beams), which was about 100 lb. per sq. ft. for an average concrete floor. The dead load of floor must be carefully calculated in each particular case.

Use of Steel in Buildings.—Steel was used in buildings where the design did not permit of the use of only brick and stone work on account of large rooms, great loads, architectural features or planning requirements. It was used by reason of economy where it was found to be cheaper than other materials, or where the floor space saved by using steel columns instead of brick wall or piers more than compensated for the extra cost of steel compared with the cost of brick. Steel beams and concrete were substituted for wooden joist floors and roofs in order to obtain a more fireproof construction, often to a considerable increase in the first cost of the building, but the fireproof building was more profitable to the owner than the old wooden construction when the reduced insurance premiums and the increased rigidity and stability were taken into consideration.

In addition to the before-mentioned reasons for using steel in buildings, there were others more or less important according to conditions or circumstances: rapidity of construction; possibility of changing the arrangement of rooms after the carcase of the building is completed; increased stability and rigidity; and uniform distribution of loads on foundations to prevent unequal settlement.

Difference between Brick and Steel Construction.—The setting out of a brick building need not be very accurate as to dimensions. The builders could set out the walls and foundations to the architect's plans and elevation drawn correct to scale, but not necessarily dimensioned. The accurate dimensions of the site were often not ascertained before the old building was taken down, and the builder ready to start work building the walls.

In the case of a steel structure, however, it was most essential that the drawings were completely worked out beforehand, and all details made.

Ventilation, heating, drainage, lighting arrangements, etc., should be set out beforehand, and the general lay-out and steel plans made to suit the different requirements.

Economy. — By the use of steel the rental floor space was increased considerably; it also permitted the use of large spans and less pillars, thereby enabling the future tenants to arrange the rooms according to their requirements. Buildings could be quickly erected and completed, thus saving interest on capital.

In order to obtain true economy, however, it was necessary that the planning and designing, and also the method of carrying out the work, should be systematical, and in accord with the general principles to be laid down thereafter.

Systematical Progress of Work.—The steelwork plans should be ready several months before work could be started on site, to allow for the time required for the manufacture of the steelwork at the mills; also it should be borne in mind that the steel could be obtained at a smaller cost if ample time were allowed for the steel contractor.

It was advisable to order the full quantity of each section in one lot, and get the pieces cut to exact lengths at the mills. Considerable waste occurred if the shop had to draw material from stock. To take material from stock should only be permitted when very quick deliveries were absolutely essential. Generally speaking, complete dimensioned shop drawings should be made in the office in preference to setting out the rivets, connections and details by workmen in the shop. Position of every rivet should be shown on the detail drawings, and nothing should be left to the judgment of the workmen in the shops. Another advantage of having complete shop drawings was that every piece could be inspected and compared with the detail drawing, and errors in shop work could more easily be detected than if the work were set out in the shop without shop drawings. Every piece could be made complete to the detail drawing, without fitting the different pieces together, and still they must fit perfectly when erected. The essential thing to remember in steel construction was that there should not be any alterations of the steelwork on the site.

Manufacture.— An inspector should be appointed by the architect or engineer to inspect the quality of material at the place of manufacture. The inspector should be at the mills when the material was rolled; also when the chemical and physical tests were made, and he should make records of the results of the tests, and order additional tests to be made if the material does not run evenly. The inspector should reject and order any material to be removed which did not meet the requirements of the specification, and should stamp and approve that which was satisfactory.

Shopwork.—From the stockyard the material was brought to the working shop, and skilled workmen marked the position of the holes, lines of cutting, etc., on the steel pieces direct, with or without template.

In the case of built-up sections, as, for instance, a column composed of angles and plates, all the angles and plates were not marked and drilled separately, but only a few holes were first drilled; the different plates and angles were then bolted temporarily together, and the whole thickness of metal were drilled through at the same time, thus saving time, and assuring greater accuracy and all holes being true.

During assembly the detail drawings should be consulted and dimensions checked. When the pieces were riveted they were sent to the milling machines if any part had to be machined, such as ends of columns or bearing plates on girders. Before assembling some surfaces must be painted, as after assembly they are inaccessible. Open holes which were to be filled with rivets in the field should be marked by the assembler, so that such holes had not to be filled in by rivets in the shop. Holes in small pieces and brackets were generally punched and rimered after assembling, but main members were drilled.

Before the finished steelwork was painted it should be examined by the inspector, and all dimensions checked. Ends of compression members which were machined must be examined, and it should be ascertained if the ends were square to the axis of the member.

The material would then receive its shop coat of paint or oil before shipment.

Erection.—The material was usually brought alongside the building on vans, and was hoisted by the erection cranes to a place on the building near to where it was to be erected, or sometimes directly placed in its final place. The different pieces were first temporarily bolted together and afterwards set to correct level and made plumb, after which all holes were filled with rivets. The steelwork should be painted immediately after erection, and if more than one field coat was applied, different colours of paint should be used.

Floors and walls were then built and fireproofing applied.

The erection of the steelwork should be two stories ahead of the floors. The floors should be put in one storey ahead of the walls as convenient. In cases where walls partly support the floors or girders the walls must, of course, be built at the same time as the steel was erected. When the carcase was complete, and the roof on, heating, ventilation, etc., were installed, partitions built and joinery and finishing completed.

It was wrong to suppose that after a good design and specification were made the responsible engineer's work was done. A good specification was of equal little use without inspection as a clever design without proper shop drawings.

The practice of taking a few test pieces from a job and sending them to a testing firm was not reliable, and was more deceiving than convincing. It might be that the piece selected would show good results, while material in other parts of the structure was bad. The material should be tested at the mills during the progress of manufacture.

Calculations and Preparation of Plans.—When preparing plans and calculations for a building the work should proceed in the following order:

1. The specification drawn up for stresses and loads.
2. The principal members for the structure to be calculated, and it should be ascertained whether the setting out of the columns and girders was economical and reasonable, and if necessary such modifications made as would improve the construction.
3. When the architectural plans were completed the engineer would calculate all the loads of floors, walls, etc., make stress sheets for each member, after which a set of plans was made and the required sizes given. The sizes of the steelwork thus obtained were drawn to scale on the architectural plans, and, where necessary, the engineer would modify the sections to suit architectural requirements; after which the architectural plans were practically completed, the shop drawings made, the contract placed with the steelwork contractor.

DISCUSSION.

Professor Henry Adams, M.Inst.C.E., in proposing a vote of thanks to the lecturer, said that the subject of steel construction was one in which he was very much interested. They had seen how careful and methodical some people could be in their work, and he thought architects might follow the example set by engineers in regard to the preparation of their drawings, and show clearly who had been engaged upon the work from the beginning to the end, an essential necessary to the accurate completion of the work. Mr. Bylander was such a great authority upon steel construction that his difficulty must have been not what to put before them, but what to leave out. Steel construction would, he thought, have been adopted in a greater degree by the building public had not the Building Act restricted them so, but now that the regulations had been altered and steel put upon a fair basis, this method of construction would go ahead. The factor of safety had well been called the factor of ignorance, as it was to allow for contingencies that one was not aware of at the time of making one's calculations. It was, however, not four as generally supposed, but only a real factor of about two, and not always that. Although steel was not a combustible material it was not fireproof or fire-resisting in itself. If they wanted a fire-resisting material it was absolutely necessary that all the steelwork employed should be encased in concrete. Too much emphasis could not be laid on that necessity.

Mr. G. A. T. Middleton, A.R.I.B.A.—He was immensely struck by the extraordinary system displayed, the insistence upon everything being done regularly from beginning to end. That every little bit of detail should be shown on the working drawings was utterly opposed to the ordinary architect's method of preparing plans for buildings, where again and again the words occurred "to be in accordance with detail," which was seldom or never supplied until the builder asked for it, whereas Mr. Bylander had said that the drawings should be ready long in advance, and accurate to at any rate a quarter of an inch. Thirty years ago steel was unknown as a material for building. Those were the days of wrought-iron work, now entirely replaced by steel for structural work. Yet steel construction was already threatened with obsolescence. It was being largely if not entirely replaced by reinforced concrete. In Normandy, he had recently found that all modern railway bridges were constructed of the latter material, and as pointed out in a German book on the subject, steelwork when exposed to the fumes of locomotives deteriorated, which could not be said to apply to reinforced concrete. It was essential that the steelwork of a building should be protected, and that the protecting material should be of sufficient thickness.

Mr. J. Herbert Pearson.—He noticed that the lecturer had emphasised the need for the exercise of economy in the use of steel as a building material, while great elaboration had been gone into in the preparation of the working drawings. Another point which struck him was that the engineer required the ventilating, lighting and drainage schemes to be settled beforehand, so that in preparing his plans for the steelwork he could make proper provision.

Mr. Edwin J. Sadgrove, F.R.I.B.A.- Mr. Bylander suggested that many errors in architectural planning might be avoided if the engineer's plans were prepared in the earliest stages of the designing, but he (Mr. Sadgrove) ventured to say that no one but an imbecile and totally unfit to be called an architect would be guilty of planning large rooms in the lower stories and smaller ones above, with heavy division walls and chimneys, without considering and providing ample support for them below. Further, he considered it was quite necessary for an architect to first of all prepare his general scheme, embodying the arrangements and conveniences required by his client, and then to consider the merits and economies of steel or other suitable forms of construction.

The Reader of the Paper replies: Mr. Bylander said he agreed with Professor Adams that the protection of steelwork in buildings was an essential thing and would have to be looked after, particularly for exterior work. A steel column placed in the centre of a building where there was practically no possibility of water penetrating was not very liable to rust and possibly not so open to destruction by fire as those on the outside of a building where the encasing material might become deteriorated by weather and expose the steel. Concrete was undoubtedly the best material for protecting steel from fire and he thought 2 in. of concrete all round the steel was sufficient if well secured. Calculations for columns in reinforced concrete work should be very carefully made, and the eccentric loading taken into account in the calculations. Stresses in steel columns could be fairly accurately figured, but not so with reinforced concrete pillars, where there were no joints between beams and pillars. Reinforced concrete properly carried out could be made perfectly safe, but they had to allow a greater factor of safety than that allowed for structural steel. A steel-framed building was, as a rule, designed to be stronger than a reinforced concrete one. He did not mean to say that the latter could not be made safe and strong, but his contention was that a factor of safety of four was not sufficient for reinforced concrete, if four was required for steel. If the Building Act required a concrete covering of structural steelwork of 2 in. in thickness a similar casing should be allowed for outside the calculated size of a reinforced concrete member, as the outer skin might be partly incapable of carrying any load after exposure to fire and water. Steel rods needed protection as well as steel beams. Reinforced concrete for floors was very satisfactory.

LONDON COUNTY COUNCIL SCHOOL OF BUILDING, BRIXTON.

CONCRETE AND REINFORCED CONCRETE.

Lecture by MR. E. P. WELLS, J.P.

Mr. E. P. Wells, J.P., engineer, Clapham, S.W., recently delivered a lecture on "Concrete and Reinforced Concrete," at the London County Council School of Building, at Brixton, of which we give a summary.

Concrete.—In the Lecturer's opinion the most important point in reinforced concrete construction was the concrete; if it was not good and would not stand a high pressure the structure was bound to fail. Dirty materials and water, poor cement, and bad workmanship were the points that had to be carefully looked into and overcome. He laid great stress on the absolute necessity for observing great cleanliness with regard to the aggregates used and also for the sand. If all the materials in the concrete were clean and the cement good they would have a concrete that would give an enormous resistance to crushing. Mr. Wells dealt at some length with the different methods of testing cement for soundness, and gave particulars of the various modes of ascertaining free lime in cement, contraction cracks, etc.

It behoved all those having charge of concrete work to be extremely careful as to the manner in which the cement was stored. Great care must be exercised that finely ground cement was not stored in an open shed where the wind could blow through, as the same became quickly hydrated and greatly reduced in value. Very finely ground cement should be stored in covered wooden bins and emptied out of the sacks directly the same was received on the site of the works, as storing in sacks was the worst method imaginable.

The quicker the cement was used after it was received on the works the better, as storing, unless in airtight bins, caused rapid deterioration, owing to the absorption of water, and partial killing of the cement.

Sand.—Great care should also be exercised that all sand was perfectly clean, because should there be vegetable matter or mud in the sand the resultant concrete would be very poor indeed. With clean sand it was possible to make a fairly good concrete, even if the aggregate were dirty, but if the sand were dirty, then no good results would be obtained, even with a clean aggregate.

One of the great secrets in the making of concrete was to ensure that all materials were clean, and if such were the case, and the cement good, they would have a concrete that gave an enormous resistance to crushing.

Consistency.—Concrete for reinforced work should always be made fairly wet, but not too wet. Where wet, very little ramming was required; in fact, a trowel would do the whole of the work. Too much moisture simply caused the cement to rise to the surface and run away, and if it was rammed too much it would still further drive the cement out. It is far better in making concrete for reinforced work to have an excess of sand than too little, as an excess would ensure a thoroughly good homogeneous concrete, and exclude air and also moisture where used in tank and other forms of construction.

Centering.—With regard to the centering required for beam, slab and column construction, too much care could not be exercised in seeing that the work was thoroughly vertical and horizontal, as the case might be. With regard to beam construction, a camber of at least $\frac{1}{8}$ in. in every 5 ft. of length should be allowed, as this invariably came out during the process of ramming the concrete.

All the folding wedges must be perfectly firm, and methods should be employed to prevent any movement of the same. It was advisable, after a beam had been filled, to see whether the camber had been taken out, and if so, while the concrete was green the folding wedges should be driven home, and so put the camber back into the beam again.

Settlement of the Supports.—In reinforced concrete beams there was often a great deflection of the beam. In nearly all cases that had come under his notice this had been due to settlement of the supports, owing to the soft nature of the ground, and he strongly advised them all, before any concrete was filled into the moulds, to ascertain that the ground was going to more than carry the weight to be put upon it. It was necessary to be careful that in no case should the strutting give owing to the soft nature of the ground.

Beam Casing.—For beam casing it was not advisable to use any wood that was less in thickness than 1½ in., and he recommended that the wood should be thicknessed. It was then easier to handle, required no packings, always had a smooth surface, and did not require the use of oil, soft soap, plaster, or a wash of any kind or description, as the wood left the concrete perfectly smooth; but where boarding was used rough from the saw, then it became absolutely necessary to put some medium on to prevent adhesion of the furred surface of the wood to the concrete.

Striking.—If possible, all shuttering should be left for at least a week, and for the beams the sides only to be struck, the bottom board being left in, as also all the struts or supports, for at least three weeks from the time the beam concrete had been filled in. This to a certain extent depended upon the weather. In the winter time, if there had been no frost, he strongly advised the strutting remaining in for at least four weeks, but for the flat plate floor, if the span did not exceed 6 to 7 ft., the timber might be struck within seven to ten days, so long as no weight was put on to the floor, but the longer the centering and sheeting were left up the better, and the stronger would be the work. In the summer time centering and sheeting might be struck within a very short time; in fact, in some cases the sides of the beams could be removed within 24 to 48 hours, especially if the cement were of extremely good quality and gave high crushing results; but if the cement were poor, then under no circumstances must the sides be removed within a week.

Reinforcement.—Concrete, owing to its nature, did not admit of any tension being put into it, so it became necessary to use iron or steel to reinforce the tension member to take up the stresses put into it.

A good cement, in setting in air, always contracted, and this contraction put into the steel an initial compression of somewhere between two and three tons per sq. in. of sectional area. This had to be taken out by loading before any tension was put into the steel. In the case of a column this initial compression was an element of weakness, and should be allowed for accordingly in column designing. In beam and floor slab construction where the steel was in tension, then it was of great advantage, because it meant that with dead load only there was practically no stress on the steel whatever, and in a great many cases the structure had to be slightly loaded before tensile stresses were put into the steel.

Placing of Steel Members.—It is a matter of great importance in the construction of this class of work that all steel members should be put in position as shown on the working drawings, and he must impress upon them the necessity of seeing that this was carried out; also that the rods had the amount of concrete round them that was shown, and were not allowed to come on to the surface and so become oxidised in time, and valueless. When the rods are first put into the concrete the same should be wet so as to ensure that they would be thoroughly embedded, after which the concrete might be slightly dryer, but then it would require more ramming.

Cement Wash.—Some engineers recommended that where new concrete was put on to old, or that which had previously set, a neat cement grout should be used as a wash. He thought the best method to adopt was to make a mortar of one part sand to one part of cement, to wet the concrete well, first scoring, if necessary, then put ½ in. of this mortar, then the concrete proper. This would also ensure a thoroughly good joint, and the mortar would work its way up into the concrete and form a homogeneous mass, whereas if the cement grout only were used, and should the first layer of concrete that was put on have an insufficiency of sand, there would never be a good joint.

The Question of Rust.—There had been a great amount of discussion in the papers as to the advisability, or otherwise, of putting rusty steel into concrete. A great many people advocated that the steel should be quite clean, and that it should be covered over with a coat of cement grout before being used. He was of opinion that before steel was put into concrete it should be slightly rusted so as to get off all the mill scale, but that it should not be badly rusted so as to form scale. Rusty steel or iron bonded better to concrete than where the surface was quite smooth. If the steel rods were well covered with concrete there was no further possibility of any corrosion taking place; in fact, the presence of lime, which, as a rule, was 60 per cent. of the cement contents, in the concrete absolutely prevented any oxidation taking place. Many people believed that, if water should by any possible chance touch the steel embedded in the concrete, it would cause the same to oxidise and in time disrupt the mass. Where stone concrete was used he had never found such to be the case.

Corrosion of Steel in Breeze Concrete was more often than not due to the presence of oxide of iron, and not to the sulphur—*i.e.*, the porous breeze concrete let the air get through to the iron. The sulphur in the breeze had a deleterious effect on the concrete; in fact, would disintegrate the concrete if there were too much sulphur in the breeze. Therefore, the breeze should never be used for concrete. Roughly speaking, the corrosion of the steel was more often due to the oxide of iron found in the breeze, which, coming into contact with the steel, induced further corrosion; but the main corrosion was due to the porosity of the breeze concrete admitting the air to the steel.

In conclusion, he wished to again impress upon them the absolute necessity for cleanliness in the use of the material employed, the purity of the water used, the efficient mixing and ramming of the concrete, its protection from sun and cold during construction, and, if lasting structures were required, the necessity of obtaining, at whatever cost, the very best unadulterated Portland cement that was made.

THE INSTITUTION OF CIVIL ENGINEERS.

THE USE OF REINFORCED CONCRETE ON THE WABASH RAILWAY, U.S.A.

Paper by E. R. MATTHEWS, Assoc.M.Inst.C.E., and A. O. CUNNINGHAM, M.Am.Soc.C.E.

"The Use of Reinforced Concrete on the Wabash Railway, U.S.A.," formed the subject of a Paper which was presented at a recent meeting of the above Institution by Mr. E. R. Matthews, Assoc.M.Inst C.E., and Mr. A. O. Cunningham, M.Am.Soc.C.E., at which Mr. J. C. Inglis, President, was in the Chair. We give the following extract.

THE Wabash Railroad Company was one of the pioneers in reinforced concrete construction, having commenced its use as early as 1902. This railway is one of the leading lines in the Middle West, and has a total length of 2,500 miles. Its headquarters are at St. Louis, and it extends to the cities of Chicago, Detroit, Toledo, and Buffalo on the east of the Mississippi River, and to Kansas City, Des Moines, and Omaha on the west. In this paper examples of bridges, culverts and pipes in reinforced concrete were described.

In designing the structures referred to, the live load was assumed to be equivalent to two coupled "Consolidation" engines and tenders, followed by a uniform train-load, placed so as to give the greatest stress in the structure. Impact stresses, which are taken as equal to the square of the maximum live-load stress divided by the sum of the dead- and live-load stresses, are allowed for; and the working stresses are obtained by combining the maximum dead-load, live-load and impact stresses. The unit stresses allowed are:

	Lbs. per sq. in.
Steel, tension on net section of rod	18,000
Steel, bond on deformed bars	100
Concrete, compression in cross bending	800
Concrete, direct compression	600
Concrete, shear (diagonal tension) in plain concrete	30
Concrete, shear (diagonal tension) when web is properly reinforced	100

The steel bars being specified to have an elastic limit of 55,000 to 65,000 lb. (24·5 to 29 tons) per sq. in., and the concrete to consist of one part of Portland cement, two of sand, and four of stone or gravel. In proportioning the concrete and steel the formulæ devised by Professor Talbot, of the University of Illinois, were employed. Most of the reinforcement used in the structures referred to in this paper consisted of corrugated bars in the form invented by Mr. A. L. Johnson. These bars are square in section, with corrugations on all four sides, the sides of the ribs being practically at right angles to the axis of the bar.

Consistency.—The concrete was what might be termed a wet mixture, it being the practice in the United States in reinforced concrete work to put in the concrete in this manner. The advantages of so doing are, first, that a more dense and homogeneous concrete is obtained; and, secondly, that the reinforcement becomes better imbedded, every portion of it being well covered by the cement; rusting of the metal is thus prevented. The authors stated that any fear as to the excess of water weakening the concrete has been proved to be groundless by the experiments carried out by Mr. G. W. Rafter for the State Engineer's office of New York.

Among the bridges described in the paper were the Sangamon River Bridge, and a bridge in Forest Park, St. Louis.

The Sangamon Bridge.—This is a double-line, four-arched skew-bridge with abutments and arches of reinforced concrete and piers of solid concrete, reinforced at the base and toes. Each pier is carried on timber piles driven into very stiff clay. The angle skew is 45 degrees; each arch has a semicircular square span of 61 ft. in the clear, and a skew span of 100 ft. between centres of piers. The arch rings are heavily reinforced with upper and lower ribs of 1-in. square rods 12 in. apart, crossed by 1-in. square rods about 4 ft. apart, laid parallel with the piers. The joints in the ribs are formed by overlapping the rods. The minimum cover over the reinforcement is 2 in., and the thickness of the concrete below the ribs in the arches varies from 6 in. at the crown to 24 in. at the springing. The features of particular interest in this bridge are the abutments and the method of providing square bearings for the arch-ribs at the skew-backs. The abutments are practically boxes divided by horizontal and vertical partitions into four compartments. The slab for carrying the road-bed is reinforced with longitudinal rods 24 in., and transverse rods 4 in., apart, the ends of alternate rods being bent up at an angle of 45 degrees. The cost of this bridge was £25,100.

The Forest Park Bridge.—This bridge consists of concrete abutments carrying an 80-ft. double-line, through-girder bridge. The abutments are of the hollow type—namely, thin reinforced face-walls supported by counterforts resting on slab foundations. The principal features are the curved wing-walls, the concrete facia and balustrade carried by the outside girders, and the other ornamental concrete work. The counterforts not only carry the girders, but also act as ties to hold the face-wall of the abutments. The reinforcement in the abutments consists of ¾-in. square corrugated rods. The bridge-floor is of concrete 8 in. thick, and is reinforced in both faces with ½-in. rods. This floor-slab is carried on 15-in. steel I -beams, which are riveted by connecting angles to the webs of the girders, and are spaced 18 in. apart between centres. The cost was £4,565, but this included the removal of an old bridge and its stone substructure; also a large amount of excavation on account of increasing the width of the opening, and the necessary temporary bridging to provide for the traffic.

Illustrations were given of alternative arrangements of solid reinforced concrete floors for various types of bridges, the cost of which varies between 16s. and 20s. per lineal foot of floor 13 ft. wide. Where it is necessary to have a watertight floor a mixture of 1 part of cement and 3 parts of coarse sand is used, but where watertightness is not necessary—*e.g.*, where the bridge crosses a stream—the slab is made of the normal 1 : 2 : 4 concrete.

Culverts.—Standard designs are adopted for reinforced-concrete box culverts for spans ranging from 4 ft. to 20 ft., and illustrations were given of the reinforcement adopted in the 10-ft. and 20-ft. culverts. In the larger sizes the reinforcement in the top and bottom slabs and the side walls is supplemented by diagonal reinforcement at the four angles of the section.

Pipes.—Reinforced concrete pipes are made in 3-ft. sections with a diameter varying from 2 ft. to 4 ft. The reinforcement consists of woven-wire fencing, supplemented by ¼-in. longitudinal bars. In the construction of the pipes inside and outside forms are used, the casing being 2 in. in thickness, and lined with No. 20-gauge galvanised iron. The 4-ft. pipes are 4 in. in thickness, the inside and outside reinforcement having a 1-in. covering of concrete.

No special test-loads are used to test a structure after it is completed, as this is considered unnecessary. Inspections are made on all bridges on the Wabash Railway, including, of course, reinforced concrete structures, by a competent inspector once every month. The engineers in charge of the divisions on which the bridges are situated also inspect them each half-year.

The authors stated that none of the many reinforced concrete structures on this railway have needed any repairs since they were built. They are very rigid under loads, and their appearance indicates that they will outlast any other kind of structure, and require no maintenance. A great many have now been in the track more than five years, carrying loads very nearly as heavy as the live load used in designing them. Attempts have been made to determine the deflection in reinforced-concrete structures due to train-loads, out none can be detected under ordinary measurements.

It is considered that sufficient time has now elapsed to demonstrate the fact that reinforced concrete is reliable; it is undoubtedly permanent, and as good as, if not better, than cut stone for the construction of bridges, culverts, and similar work; it is certainly cheaper. Compared with steel, reinforced concrete is altogether superior, as it requires no maintenance. It is thus in most cases preferable to other kinds of construction, and is used where possible on the Wabash Railroad.

THE CONCRETE INSTITUTE.

REINFORCED CONCRETE BINS.

By H. KEMPTON DYSON (Secretary, Concrete Institute).

Mr. H. Kempton Dyson read an interesting paper on "Reinforced Concrete Bins" before the Concrete Institute, at their Tenth General Meeting on the 26th May. Professor Henry Adams, M.Inst.C.E., presided, and a number of lantern slides were shown.

AMONG the varied uses to which reinforced concrete is now put the construction of bins for the storage of materials of various kinds, the author considered, took an important place. Reinforced bins had been constructed for holding grain, coal, cement, ore, broken stone, sand, and other materials. It seemed established now that not only did reinforced concrete possess in a supreme degree the qualities of fire-resistance and long life, in which respects it was superior to steel, that had been used largely for the construction of silos in preference to timber, but it originally cost no more and sometimes less than steel, while the cost of frequent painting and repairs was saved. Steel bins cost 50 to 100 per cent. more than timber bins of moderate size.

Reinforced concrete bins were classified by the author into two main divisions: (1) those of large size without separate divisions and having relatively large area in respect to height; and (2) those of cellular construction, having compartments of rectangular, square, round, or hexagonal cross-section. The silos in both divisions were usually charged with materials from the top either by direct dumping from railway wagons or carts or by means of conveyors.

The first division chiefly became the problem of the retaining wall so far as design was concerned. The paper described some reinforced concrete bins of this type. Such bins are usually required to discharge material by gravitation, and they were most often built with bottoms sloping one way to two sides or to all sides, and delivering the material through side gates.

The second division entailed rather different mathematical analysis in the design, and the paper was chiefly concerned with the description of reinforced concrete bins of such cellular type, which likewise discharged their contents by gravitation, but generally, because of their shaft-like arrangement, were made to discharge the material directly under them from their lowest point to a centric or eccentric hole, and occasionally through side openings. These cellular silos might be again subdivided into (1) suspension bunkers; (2) circular bins; and (3) hopper bins. The first were constructed by suspending, from two side girders, the bottom, which was curved to assume the form of the equilibrium polygon, the stresses in the containing surface of a truly formed suspension bunker thus being purely tensile ones. In this connection it might be remarked that some suspension bunkers had been built of steel plates with a reinforced concrete lining. The circular bins (the second subdivision) were constructed with spherical or conical bottoms, and the stresses were circumferential tension and vertical compression in the cylindrical sides, and tangential and circumferential tension in the bottoms. The third subdivision included the square, rectangular, and hexagonal bins, in which there were bending stresses introduced as well as direct tensile and compression stresses. The square hopper bins were perhaps the more usual type of reinforced concrete bin in this country.

The calculation of the pressures upon the side walls and bottoms of bins, the author stated, had been the subject of a fair amount of experiment and theorization, but in those of large size the lateral pressure was determined by the ordinary retaining wall theories, about which there had been a great deal of theorizing and very little experimentation. The theorists, however, worked upon two main lines of thought, namely, that of Coulomb's theory of the prism of maximum pressure and Rankine's theory of conjugate stresses. Though the variants on these two theories were very numerous, there were really only two mathematical processes of treating the same fundamental idea. They were only special cases of a single general equation.

The paper then gave formulæ for retaining walls, shallow and deep bins, circular bins, suspension bunkers, and special applications of reinforced concrete, together with tables containing experimental data and diagrams to save labour in designing bins.

Some tests have shown great increase of pressure when material was in motion in bins, but only in the cases where discharge openings were at the sides, which established the importance of such openings being in the centre, for the pressures in motion with side openings were in some cases four times as great as when at rest. When, however, the grain was discharged at the centre, the maximum variation did not exceed 10 per cent.

Reinforced concrete, apart from its fire-resisting qualities and long life, possessed some distinctive advantages as regards resistance to stresses in bins. It so happened that the horizontal reinforcement in the walls of cellular silos when resisting the bending induced by one cell being loaded while the adjoining one was empty, was not called upon to develop more than half the anchorage resistance that would require to be developed with all pockets filled simultaneously. Likewise when the anchorage stresses were greatest the bending was *nil*, because adjoining pockets were filled. Therefore the reinforcement for the walls afforded at the same time the best anchorage for them, and it served both functions in turn.

The corners of cellular bins in the interior of a collection were usually considered to be completely fixed, and therefore the moment at the centre was taken as $\frac{pl^2}{24}$ and in the corners as $\frac{pl^2}{12}$, where p = the unit pressure. In order to obtain the greater resistance moment thus required at the corners recourse was usually had to the expedient of doubling the thickness of the walls there so as to use the same amount of horizontal reinforcement. The splaying of these corners serves other advantageous purposes in theory and practice.

It was not easy to get exact figures of the cost of erection of various bins and silos, especially in this country. In America the reinforced concrete storage bins at the Santa Fe Elevator, Chicago, Ill., cost 20 cents per bushel of storage capacity, whereas the timber working house at the same place cost $1 per bushel of storage capacity, exclusive of power plant; the machinery was, however, unusually expensive, and this made the cost high.

The working house of the Santa Fe reinforced concrete elevator at Argentine, Kas., cost 60 cents per bushel of storage capacity, exclusive of power plant, while the bins there cost 20 cents per bushel.

Regarding this country, a silo containing 440,000 cu. ft. grain, with bins 8 ft. square, worked out at 8d. per ft. cube of grain capacity, or 6d. per ft. cube of total cubical contents. Bunkers standing on legs containing 10,280 cu. ft. of coal worked out at 1s. 5d. per ft. cube coal capacity and 7d. per ft. cube on total cubical contents, while others somewhat larger cost 11¼d. per ft. cube of coal capacity or 5¾d. per ft. cube on total cubical contents. Some maize silos in London for 167,400 ft. cube of material cost 1s. per ft. cube of grain capacity or 6d. per ft. total cube. Some silos in Dublin containing 33,000 cu. ft. of grain cost 7¾d. per ft. cube of grain capacity.

Then followed a description of various ore and stone bins, coal bunkers, sand and cement storage bins, and grain silos erected in this country and abroad, illustrated by lantern slides from photographs and working drawings.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE FACTORY AT BAILIFF BRIDGE, YORKSHIRE.

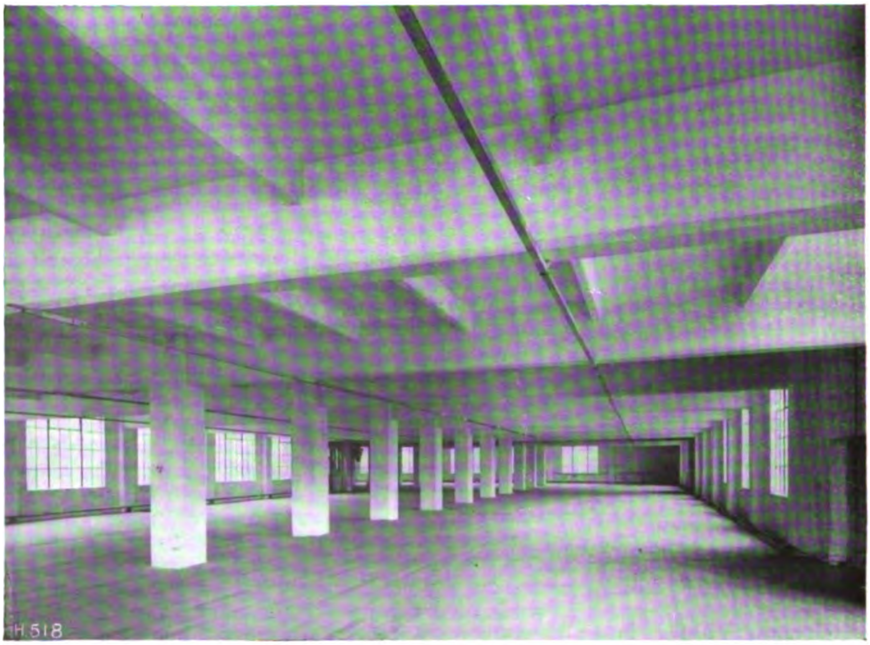
A LARGE reinforced concrete factory and warehouse has recently been completed on the Coignet system at Bailiff Bridge in the West Riding of Yorkshire. The buildings are an extension of the works of Messrs. T. F. Firth & Sons, Ltd., and are used for the carpet industry.

The main building is four storeys high, 176 ft. long, and has a total floor area of 52,000 sq. ft. Each floor has a span of 70 ft. at one end, and 111 ft. at the opposite end, the building on plan being in the shape of a letter " L ".

Connecting the new building to the existing works are two reinforced covered bridges, a view of one being shown on page 440, of nearly 50 ft. span over the main road, and these present an interesting feature of the scheme.

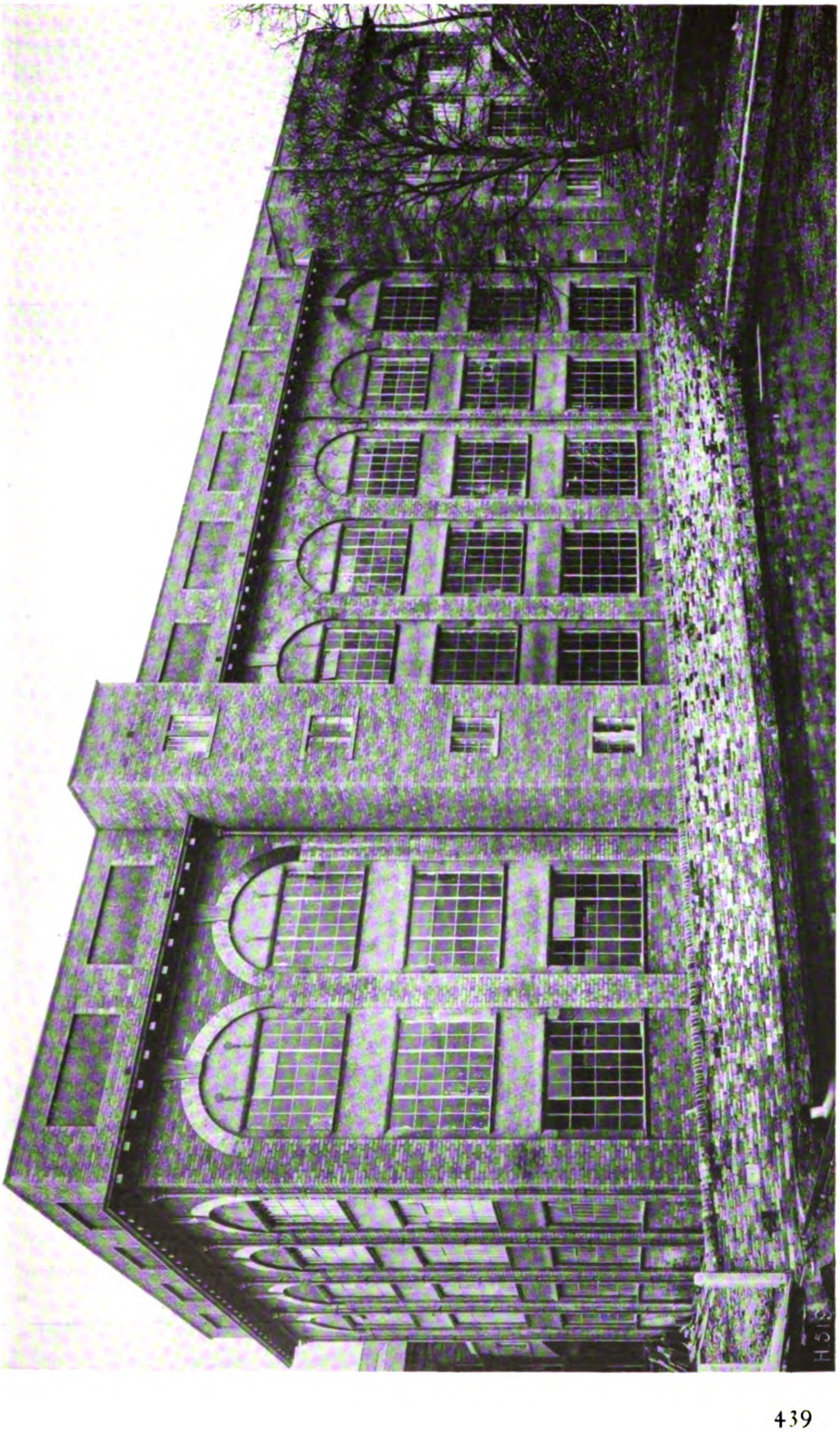
To overcome difficulties of levels on the site from the ground to the 1st floor, a retaining wall, 16 ft. high, was constructed, and reinforced concrete was found very economical for this purpose. The main staircase from top to bottom is of reinforced concrete, cast " in situ."

In designing the structure only one row of concrete posts was allowed in the minimum width of 70 ft., and the various floors had to be sufficiently light for weaving purposes.



View of interior.

FACTORY AT BAILIFF BRIDGE, YORKS.

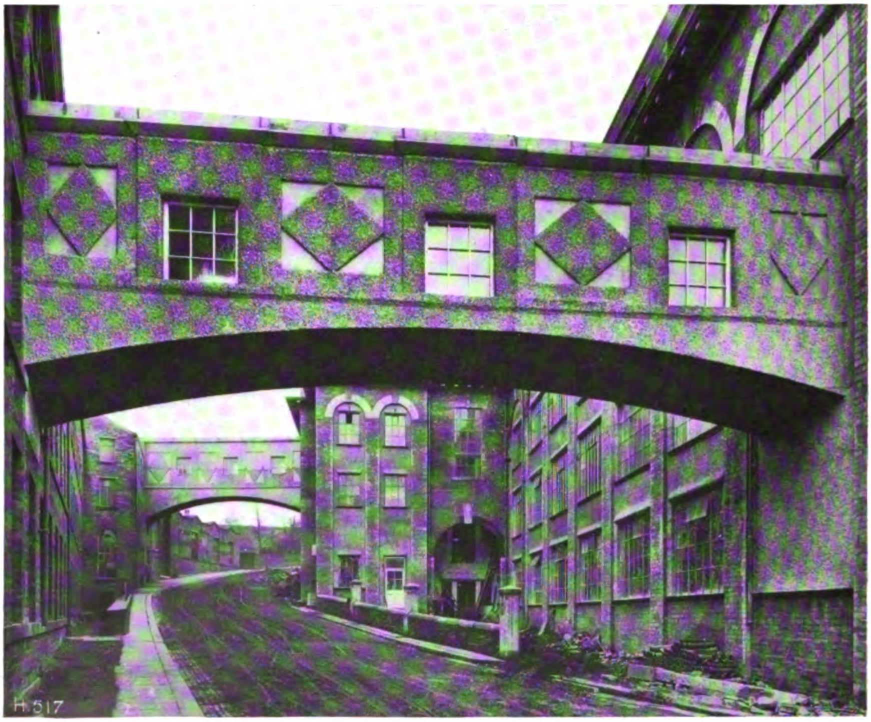


Factory at Bailiff Bridge, Yorks.

The work being situated in the very midst of the York stone district, local prejudice prevented treating the work externally as a distinctly concrete building. By facing the main reinforced concrete posts supporting the beams of the various floors with local self-dressed wallstones 5 in. on bed, a compromise has been effected. The recessed wall spaces under the salt-glazed brick arches are finished with rough cast, and quite 1 ft. 6 in. to the width of the building is added to the floor area on every storey compared with ordinary wall construction, to comply with the local building by-laws.

It is interesting to note that this large factory does not exceed in price per super yd. of floor area a similar factory built twelve years ago in the same neighbourhood, and built of steel girders and stanchions, with wooden floors and stone and brick walls.

Fires are very frequent in this district, causing tremendous inconvenience, and reinforced concrete was, therefore, found particularly useful in this case, as loss by fire is greatly minimised by its adoption.



Connecting bridge of reinforced concrete.
FACTORY AT BAILIFF BRIDGE, YORKS.

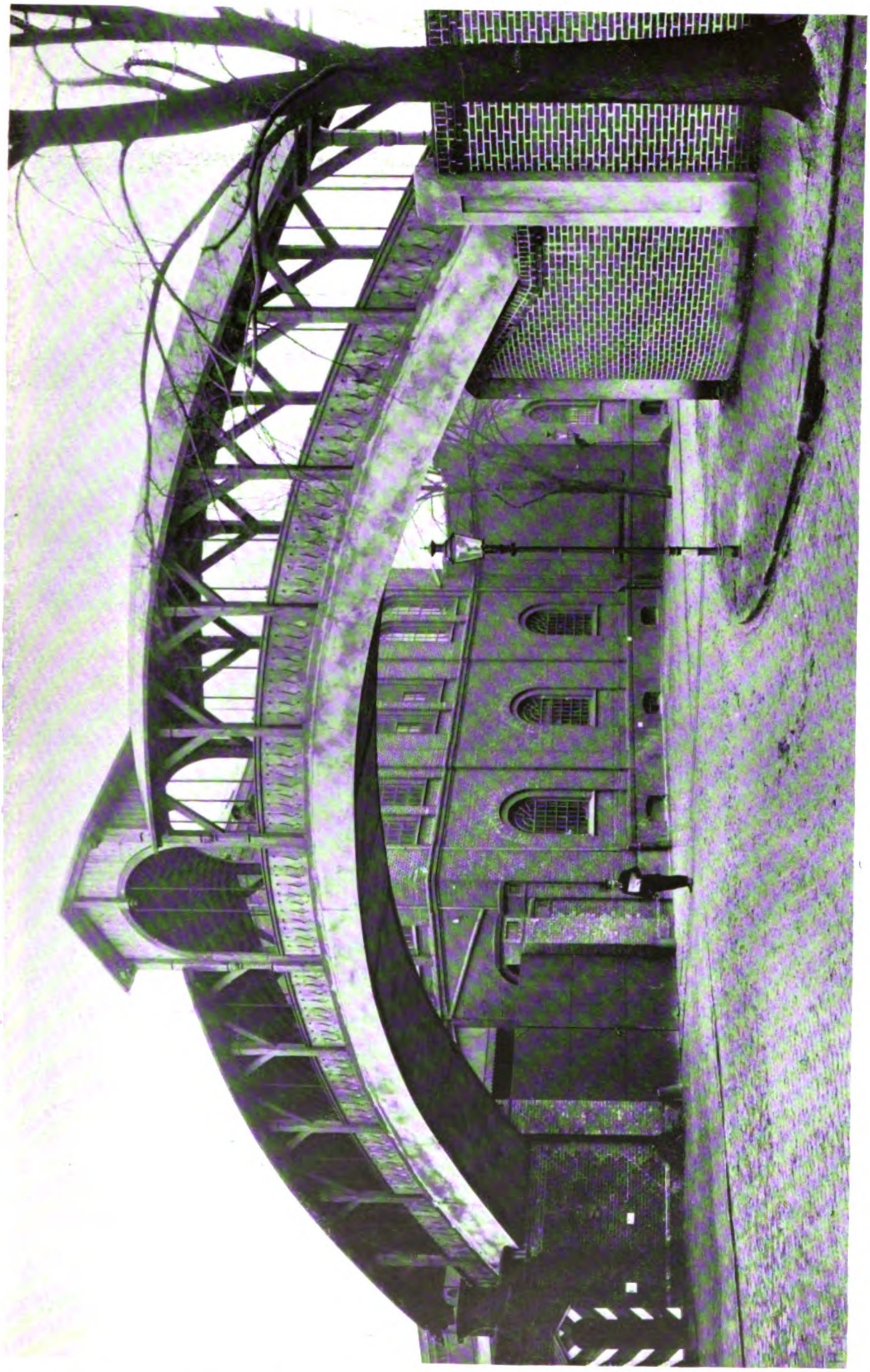
Another advantage to be shown is the low rate of premium insurance companies are prepared to cover buildings constructed of reinforced concrete, and in this particular case a saving of 300 per cent. has been effected on the yearly premiums.

The floors have been designed to carry $2\frac{1}{2}$ cwt. per ft. super, with a factor of safety of 4.

The architects were Messrs. Walsh and Nicholas, of Halifax, and Messrs. Henry Atkinson & Sons, of Carlton Hill, Leeds, contractors and licensees of the Coignet system, executed the whole of the work.

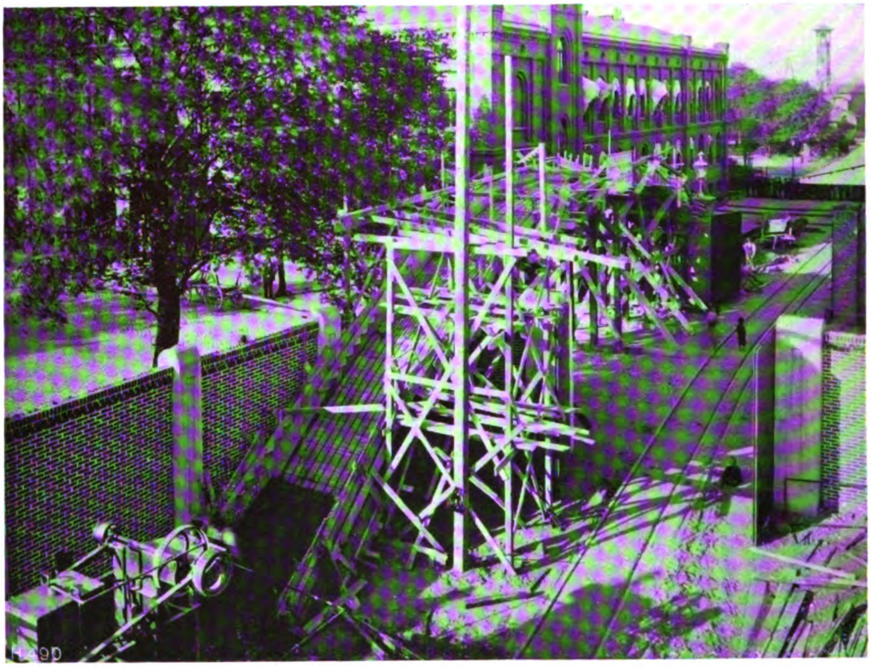
REINFORCED CONCRETE BRIDGE FOR THE KIEL DOCK WORKS.

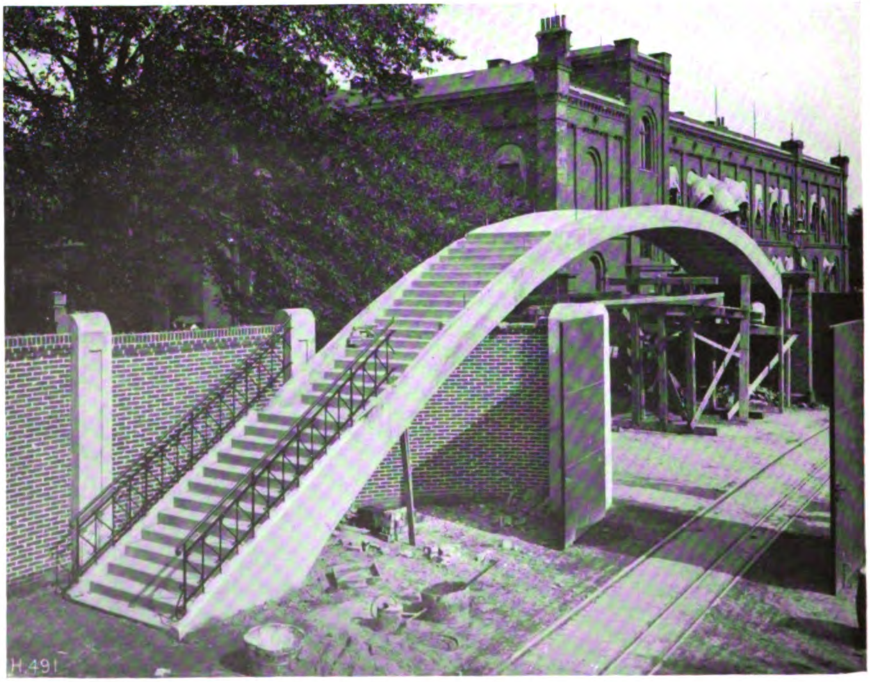
THE bridge in our illustration was built to connect up the different docks which have lately been erected in Kiel, and to provide means of transit for the employés of these docks, and for small merchandise. This structure is an excellent example of the



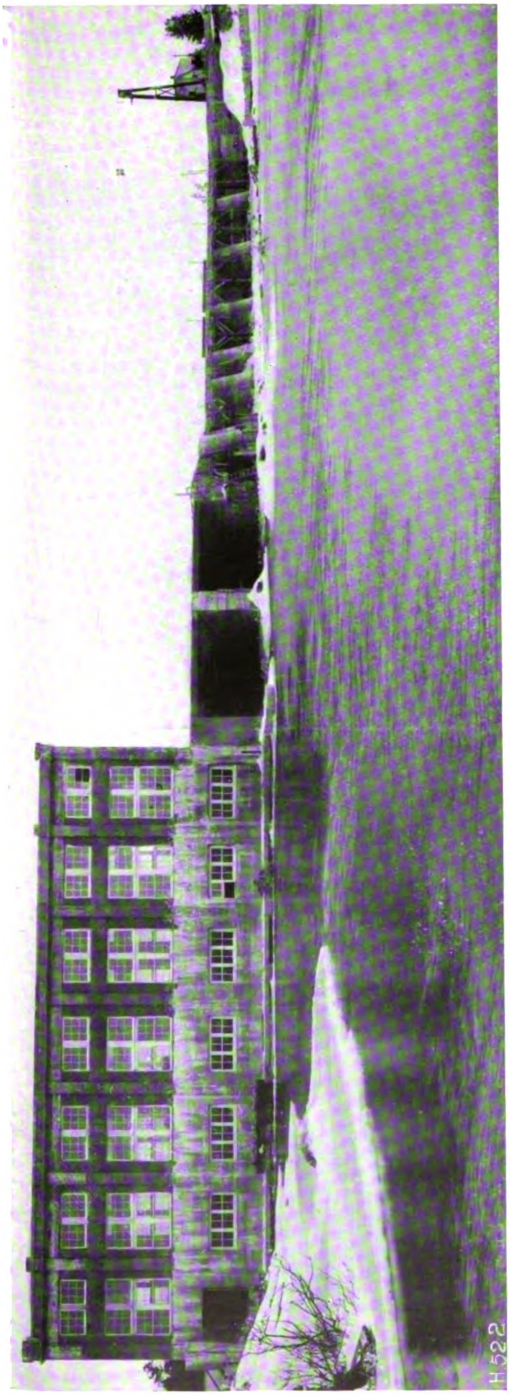
Reinforced Concrete Bridge for the Kiel Dock Works.

advantageous use of reinforced concrete even for works which are not of great magnitude.





Views showing bridge in course of construction.
REINFORCED CONCRETE BRIDGE FOR THE KIEL DOCK WORKS.



CONCRETE DAM AND PUMPING STATION, PETERBOROUGH, ONTARIO.

Owing to scarcity of stone and the cheapness of steel there, and particularly to the fire-resisting and lasting properties of reinforced concrete, this bridge, as well as many of the workshops and magazines in connection with the docks, was made of this material.

After much consideration, the engineers, Messrs. Weirich and Reinken, of Kiel, determined to erect a triple-hinged bridge, and the artistic architectural effects obtained by them are easily seen in our illustrations.

The span of the arch is 27 metres, with a rise of 5 metres.

The working load was taken at 400 kilog. per sq. metre, and the exact stresses were calculated according to the latest regulations of the Prussian Ministry of Public Works. As the work was not one of great magnitude, the concrete was mixed by hand in the proportion of 1 : 5 for the arch and 1 : 6 for the abutments. The steps are made of plain concrete, and were formed direct into the arch. The parapet and roof are of wood. The forms for the bridge and the iron supports are shown on page 442; also a view of the bridge as it was at the time the loading test was undertaken.

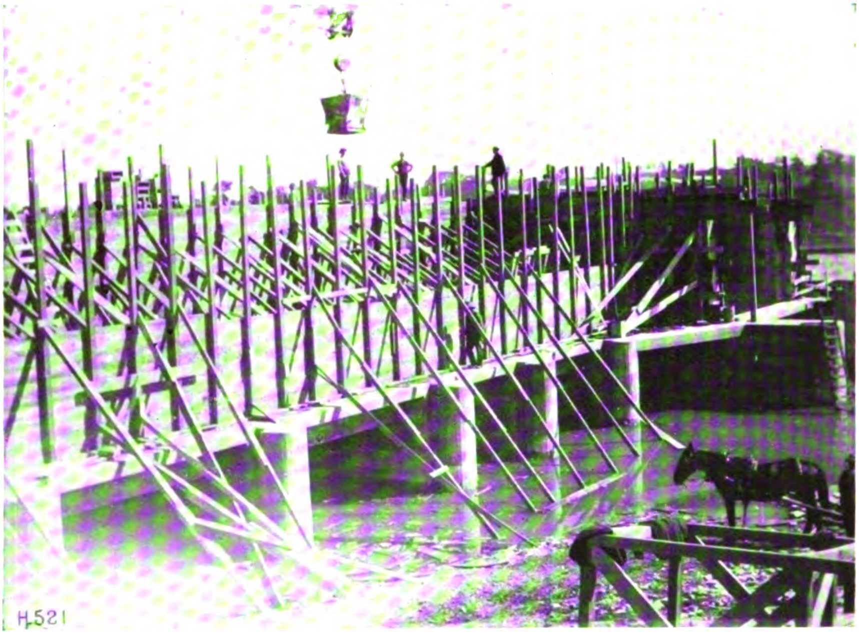
THE NEW CONCRETE DAM AND PUMPING STATION AT PETERBOROUGH, ONTARIO.

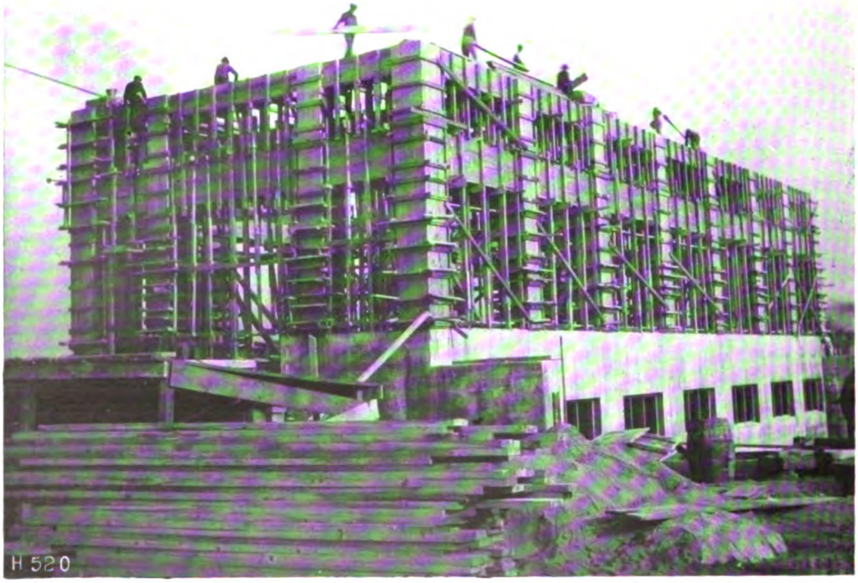
THE new dam built for the City of Peterborough, Ontario, is a striking example of modern concrete construction, and is admitted by experts to be one of the finest pieces of such work in Canada.

The dam is built of concrete in the form of a series of concrete piers, with a lower dam below the lowest level of water, and the intervening space between this lower dam and the height of water required is controlled by stop-logs, thus giving the proprietors the full control of the water to be raised or lowered at will.

Our illustration on page 444 shows the work well advanced and the method adopted to place the concrete in forms. A cableway was erected on the banks of the

Showing method of placing the concrete.





View of Pumping Station in course of construction.

CONCRETE DAM AND PUMPING STATION, PETERBOROUGH, ONTARIO.

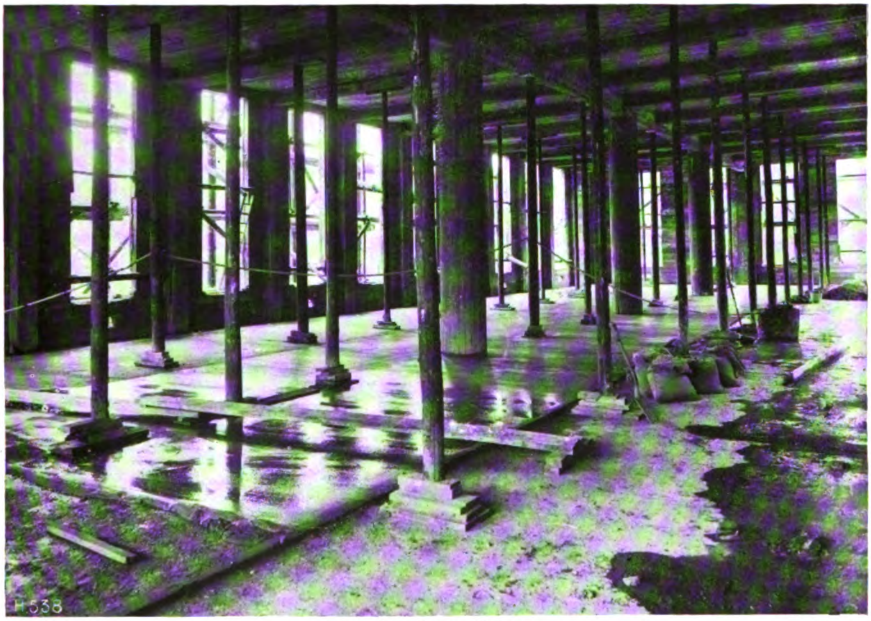
river, and concrete conveyed in a bucket of 1 yd. capacity. Owing to the poor nature of the rock it was deemed necessary to put in a layer of concrete the whole width and depth of the development works, to the depth of 18 in.

The construction is a series of piers and sluices, the grade at base of piers being 57·06, and at bridge floor, 83·00. The piers are 4 ft. thick, sluices 20 ft., with a log slide 6 ft. wide. The bridge floor is of concrete 15 in. thick, with longitudinal and transverse reinforcement. The whole of the stop-log channels are bolted to 15-in. channels that cross the 20-ft. sluices, thus forming a solid steel connection from west to east abutments.

The situation of the new dam is 888 ft. lower down the river than the old dam, and the water having to be raised to a level of 81·60, it was necessary to build watertight embankments along the river banks. The construction of this work took the form of an earthen embankment with a slope of 1 in. 1·50, with a concrete core wall running the whole length of the embankment.

The pumping station is connected with this development scheme, shown in the illustration on page 444, consists of a series of concrete pillars, the intervening space being fitted with windows and red-pressed bricks, with a concrete belt-course above the windows and under the roof.

The interior dimensions of this building are 110 ft. long, 39 ft. wide and 28 ft. high. The roof is of concrete, supported by 3-ft. girders across the building and 12-in. I-beams running longitudinally. The top portion of the roof is boarded with lumber, with an air-space of an inch between it and the concrete, thus reducing the condensation to the ceiling in power-house. A roofing felt was then laid on the boarding, making a good, watertight roof.



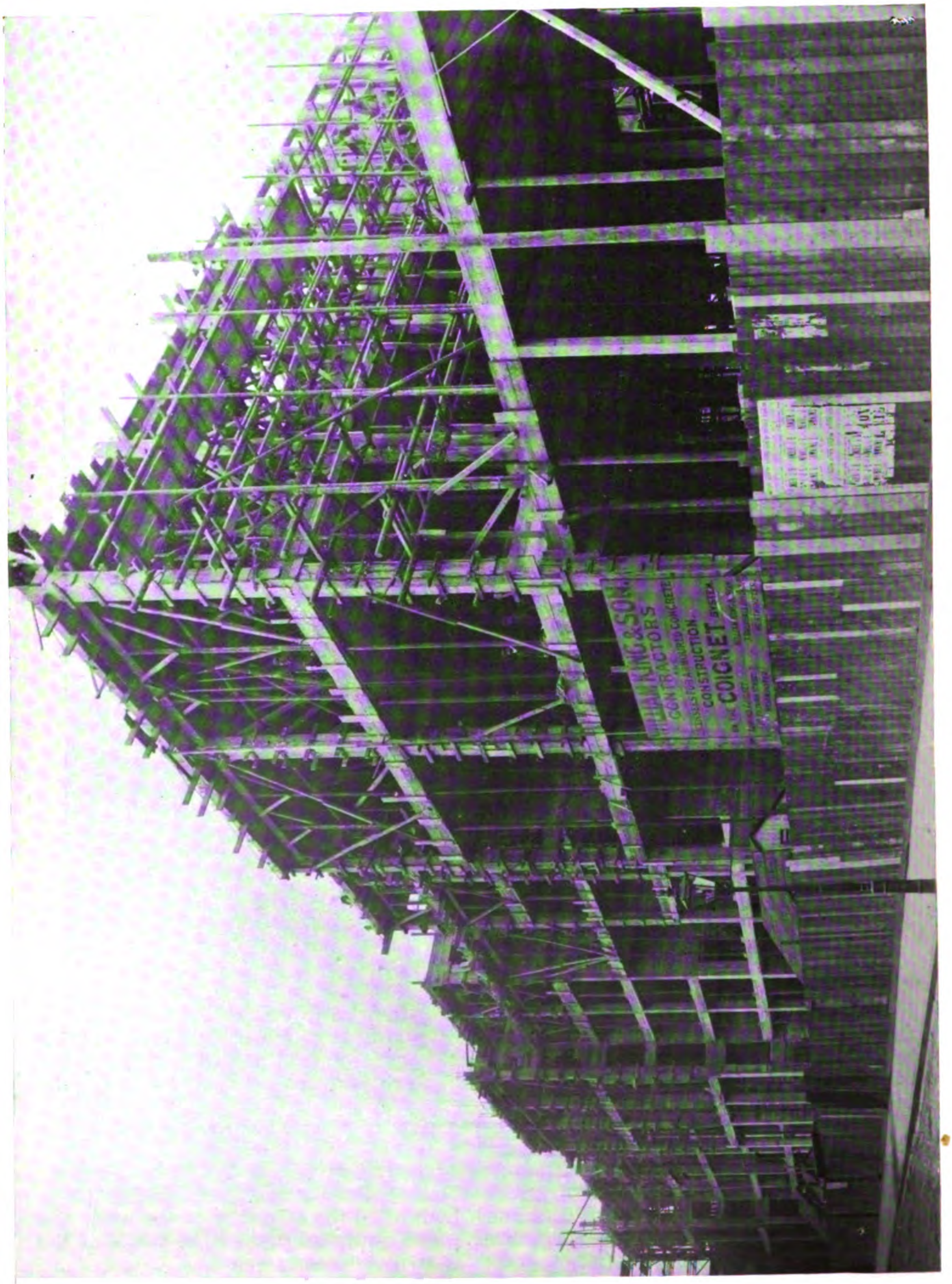
Interior of ground floor.
MONEY ORDER OFFICE, HOLLOWAY

The City of Peterborough now has a pumping capacity of 10,500,000 gallons per day in their new development.

The whole of the work was set out and supervised by Mr. A. W. Ellson Fawkes, Resident Engineer on the Works for the City of Peterborough, and it has given complete satisfaction to everyone concerned, both as to the efficiency of the work and speedy method in which it was constructed. The estimated cost of the whole of the development is $200,000,000 (£40,000,000).

MONEY ORDER OFFICE, HOLLOWAY.

In our April number we gave an account of this building, which is being erected under the instructions of H.M. Office of Works. As then mentioned, the entire construction, with the exception of the front wall elevation, is in reinforced concrete on the Coignet system. Our previous photographs showed the centering for the pillars, floors and



Money Order Office, Holloway.

walls. We are now able to present an illustration showing the work much further advanced, as well as a view of interior of ground floor.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

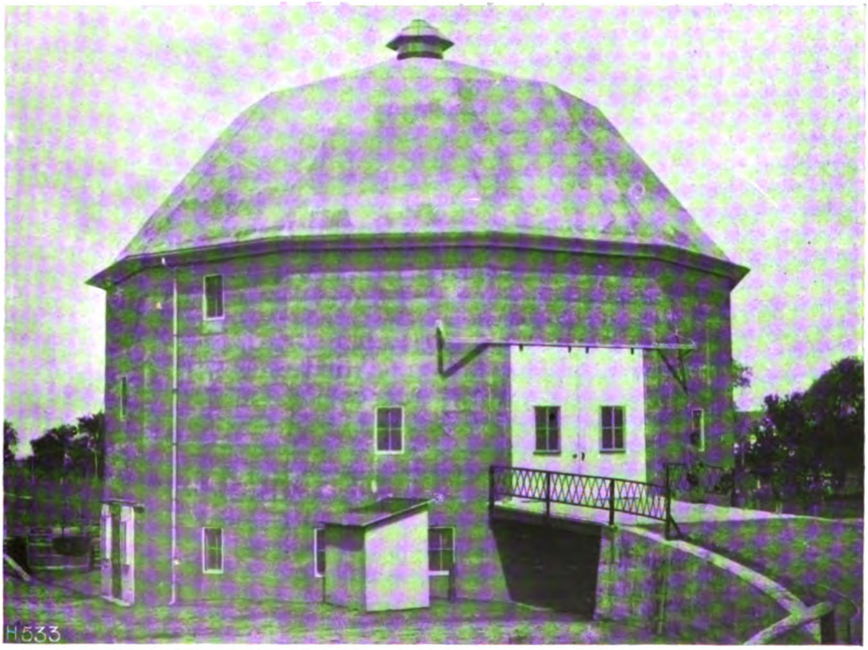
Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE BARN.

THE barn shown in our illustration was built in Shipshewana, Indiana, by Mr. S. Yoder. It is a twelve-sided building, 60 ft. in diameter, each side being 16 ft. long. It is built of solid cement concrete, 30 ft. high above the ground floor, and reinforced with rods of heavy wire fencing put in the middle of the wall. At the sides of doors and windows and above them the walls are further reinforced with old iron. The wooden door and window-frames were specially designed to be taken out after the cement was well hardened.

The foundation is 3 ft. 6 in. wide at the bottom and slopes in from both sides to the surface of the ground, where the main wall begins 12 in. thick. The concrete for the foundation was mixed one part cement to six parts gravel, and stones were tamped in. Above ground no stones were tamped in the walls, and concrete was mixed one to five. The walls are 12 in. thick one-third of the way up, and then 10 in. thick, and the upper third is 8 in. thick.

The ground floor of the barn is all cemented and has a driveway through the centre with a row of stalls and mangers on each side.



REINFORCED CONCRETE BARN AT SHIPSHEWANA, INDIANA.

Special attention was devoted to the ventilation. There are six 8-in. inlet ventilations through the walls of the stable and one outlet ventilation 27 in. by 27 in. There are thirty-one windows in the barn, all 12 in. by 12 in. glass, with four lights to each sash; all are protected inside and outside by heavy wire screens. There are no window-frames and door-frames in the walls to rot out. The window sash fits into cement, and is held there by common window bolts which fasten into small oak blocks in the cement.

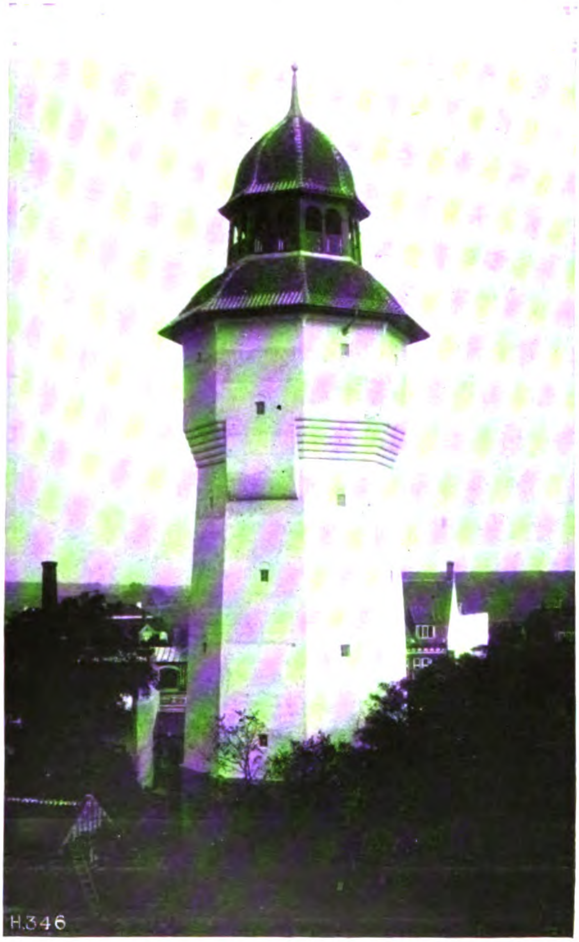
Reinforced Concrete Coal Trestle.

This barn has been found very satisfactory, as it is easy to keep clean, and experience has shown that with less than half the stock which could be stabled the temperature in cold weather has been from 20 to 27 degrees warmer than outside.

REINFORCED CONCRETE COAL TRESTLE.

THE illustrations on page 448 are of a coal trestle and bins constructed for H. B. Rosenberger, dealer in coal, etc., of Doylestown, Pennsylvania, and they are a good example of the practical use of reinforced concrete for work of this character. They were erected under the supervision of the Engineering Department of the Philadelphia and Reading Railway Company.

The trestle is about 135 ft. long. The piers and beams are of reinforced concrete. The bins are spaced 13½ ft. The plans for the trestle were made by the Philadelphia Fireproofing Co., who furnished the reinforcement.



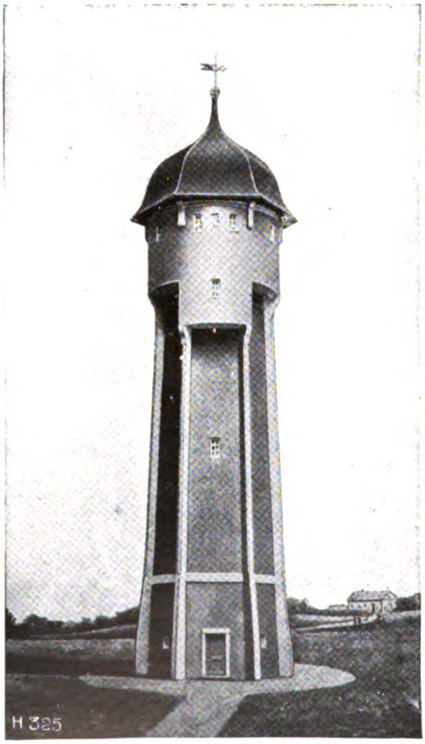
REINFORCED CONCRETE WATER TOWER AT NYKOBING, DENMARK.

The bins are far superior to wooden structures, both as to durability and economy, and they have proved very satisfactory to the owner.

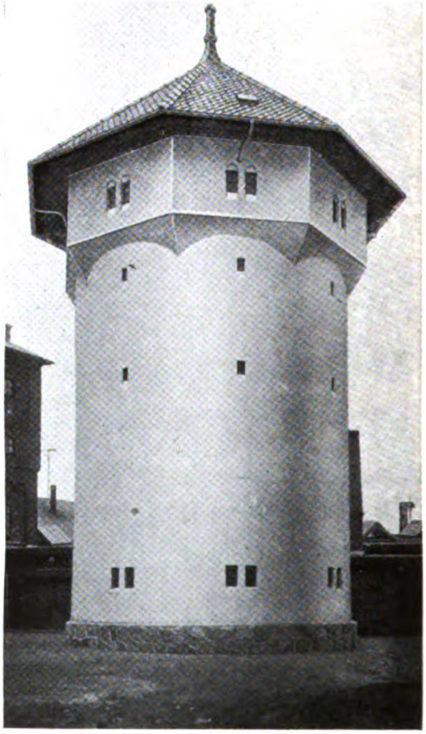
REINFORCED CONCRETE WATER TOWER.

WE have, at various times, given particulars of the use of reinforced concrete for water towers, and are now adding illustrations of some which have been erected of this material in Scandinavia. The water tower on this page is situated at Nykobing, Denmark. It was designed and built by the firm of Christiani and Nielsen, Copenhagen, entirely of reinforced concrete. The reservoir, the bottom of which is 22 metres above the ground, is cylindrical, 904 cm. in diameter and 640 cm. high, and has a capacity of 400 cubic metres. The sides of the reservoir and the four pillars inside it support a deck to which access is obtained by steps outside. An octagonal cover has been cast round the receptacle at a distance of 70 cm. from the latter. The bottom of the reservoir is supported by eight pillars placed around and four pillars forming a square in the centre. The pillars are connected by beams. The bottom plates are reinforced crosswise and with brackets at the beams.

Beams are inserted in four places between the ground and the bottom of the reservoir, and the eight outside pillars are further strengthened by the cover which has been cast between them.



WATER TOWER AT SAXKOBING.



WATER TOWER AT GEDSER.

A heavily reinforced foundation plate has been placed under each pillar. The dimensions of this foundation plate are 3·09 m. by 2·90 m. beneath the outer pillars and 2·40 m. by 2·40 m. under the central pillars. These plates distribute the pressure evenly, and in order to prevent one of the pillars sinking more than the other the reinforced concrete plates were 30 cm. thick.

The diameter of the tower at the ground is 12·24 m., and the height 43 m. The roof is of wood attached to the cover of the reservoir.

The two towers illustrated above are also built of reinforced concrete. The one erected at Gedser is 18·5 metres high, and has a capacity of 200 cubic metres. The Saxkobing Tower is also built entirely of reinforced concrete, and the total height is 30 metres. There is a gallery between the tower and the reservoir giving an excellent view of the surrounding country. These towers were also built by Messrs. Christiani and Nielsen.

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

CERESIT WATERPROOFING.

AMONG the exhibits at the recent Municipal and Health Exhibition at the Agricultural Hall, N., one of the most interesting to our readers was that of the British Ceresit Waterproofing Co., Limited, of 326 Caxton House, Westminster.

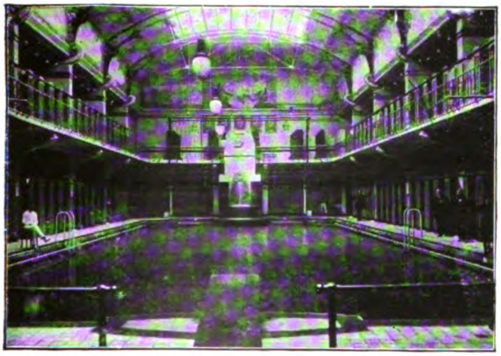
It is claimed for Ceresit, the product of this firm, that it provides a most efficient and at the same time highly economical method of making cement and concrete absolutely waterproof.

Ceresit is a preparation which originated in Germany, and during the past three years it has been used with great success in that country and in other parts of the Continent, as well as in Egypt, Siam, and America. It is described as a cream-white paste of about the constituency of butter. When added to water, in the proportion of one to twelve, it dissolves immediately, turning the water to a milky-white fluid. If this is used in the same way as ordinary water in the mixing of cement or concrete, it makes the latter completely proof against the penetration of moisture or water, even under a pressure as high as 70 lb. per sq. in.

CHÂTEAU AT STERNEBECK.

It is also claimed for Ceresit that it is sufficiently elastic to contract and expand under varying extremes of temperature, thus avoiding all likelihood of damage through extreme heat or frost.

All this is effected without any increase in cost of labour. The water in which the Ceresit is placed mixes just as easily with cement as other water. There is no smell, and the only difference in the colour of the finished cement is that it is a very little lighter than when made in the ordinary way.



BATHS AT LIÉGE.

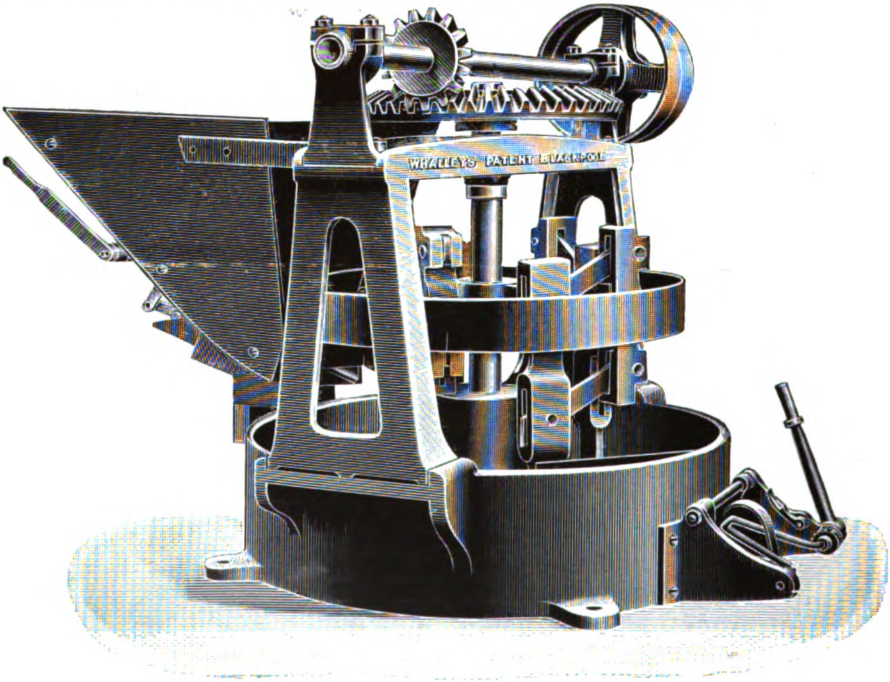
Our illustration of a château at Sternebeck and baths at Liége show two among the many hundreds of structures in which Ceresit has been used with success. In this country it is already in use by the Tunbridge Wells District Council, the Cleckheaton U.D.C., and the Congested Districts Board for Ireland.

WHALLEY'S CONCRETE MIXER.

A NEW and interesting concrete and tar macadam mixer has lately been put upon the market, the selling agents being Messrs. Bristowe and Co., Limited, Westminster, at whose office, 20 Tothill Street, a complete working model may at any time be inspected.

The advantages claimed in the invention are a minimum of wearing parts and power to drive, together with an arrangement for the complete observation of the process.

In construction there is a stationary pan, in place of the usual heavy rotary drum, into which the materials are discharged from a simple hopper of given capacity. The action of mixing is from stirring members mounted on arms radiating from a rotary and vertical shaft. Each of these stirrers comprises a vertical cutting and scraping portion, which is almost in contact with the bottom of the pan.



WHALLEY'S CONCRETE MIXER.

The material over the bottom surface of the pan is thoroughly agitated in one complete revolution of the shaft. The stirrers are so arranged that they tend to force the contents towards the sides of the pan, so that when the mixing has been completed a door in the wall of the pan is opened and the mixture completely discharged by the continued rotation of the shaft. Any jamming or clogging of the contents or damage to the machine is prevented by the manner in which the door and the stirring members are arranged. The only parts of the machine liable to wear or replacement are the bottom portion of the stirrers, which can be readily detached and replaced at a negligible cost.

The mixer is made in three sizes, $\frac{1}{3}$, $\frac{1}{2}$, and 1 cubic yard, and can be supplied on carriage; also with vertical engine and boiler. The power required for the largest size is estimated at 6 h.p.

The operation for mixing and discharging one ton of concrete requires two minutes, and any adjustment in the treatment of the materials may readily be made owing to the fact that the whole operation can constantly be observed.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the past year.

Concrete-Steel Construction. By Professor Emil Mörsch of the Zurich Polytechnic. Translated by E. P. Goodrich.

Published by Constable & Co., Ltd., London. Also by the Engineering News Publishing Co., New York. Twenty-one Shillings net.

Contents.—Slabs.—T-Beams. — Columns. Arches.—Strength and Elasticity.—Steel.—Concrete: Strength and Elasticity of Concrete; Elasticity Test of Concrete. — Shear. — Adhesion. — Torsion. — Extensibility. — Compression.—Simple Bending.—Rectangular Sections: Slabs.—Rectangular Sections, Double Reinforcement.—Actual Ultimate Bending Tests of Reinforced Slabs in their Relation to Theory.—Bending Tests of Concrete Beams with Double Reinforcement.—Bending with Axial Forces. -Bending with Axial Tension. — Graphical Methods of Calculation. -Method of Computation for Stage II*a*.—Effects of Shearing Forces.—Formulas for Shearing and Adhesive Stresses.—Experiments Concerning the Action of Shearing Forces.—Stuttgart Experiments Concerning Shear, Continuous Members, etc.—Deductions from the Experiments.—Shearing Stresses in Beams of Variable Depth. -Deformation.—Computation of Forces and Moments.—Experiments with Continuous T-Beams. — Historical. — Buildings.—Stairs.—Arches in Buildings. - Spread Footings. — Sunken Well Casings.—Water-tight Cellars. Piles. — Bridges: With Horizontal Members, Slab Culverts, Arch Construction.—Reservoirs: Silos.

Appendix. — Preliminary Recommendations for the Design, Construction, and Testing of Reinforced Concrete Structures. Appendix to the Foregoing Recommendations regarding Methods of Calculation to be used in Testing Reinforced Concrete Structures.—Regulations of the Royal Prussian Ministry of Public Works, for the Construction of Reinforced Concrete Building, May 24th, 1907.

From the point of view of the engineer-designer of reinforced concrete Prof. Mörsch's treatise is the best that has been published on such construction. The first edition of this work was published by the well-known Continental firm of constructors, Messrs. Wayss and Freytag, their object being to familiarize those interested in the scientific principles of reinforced concrete with all the experimental researches available at that time, so as to counteract the danger of reinforced concrete forfeiting a large proportion of the confidence it already enjoyed if a few failures occurred owing to the pushing of systems based on wholly unscientific methods of calculation. Soon after its publication the *Verband Deutscher Architekten und Ingenieur-Vereine* and the *Deutscher Beton Verein* published their "Leitsätze," and the Prussian Government issued its regulations ("Bestimmungen"), both of which supposed a knowledge of the principles of scientific designing which could not be obtained from works then published. Prof. Mörsch had been greatly concerned in the compilation of the recommendations ("Leitsätze") referred to, and he felt compelled to bring out a second edition of his book, which he completely revised in accordance with further experimental data available. The author has for some years acted as Director of the Technical Bureau of Messrs. Wayss & Freytag, who have had 20 years' experience of reinforced concrete construction, and therefore he was eminently fitted by practical experience for the work of compiling a handbook of use to the designer. In this book he has only illustrated examples from the work of his firm, and he cannot well be charged with being unfair in this, for he does not claim the book to be exhaustive or to embrace the whole field; he has the very good reason for only giving his own work that he knows it has been designed in conformity with the theory put forward and that it serves to exactly illustrate his remarks. The third German edition, of which this is a translation, was issued in 1907, and was extended with further experimental data. It has been a very public-spirited work that Prof. Mörsch and Messrs. Wayss & Freytag have performed in thus frankly explaining the most approved methods of design and giving the results of their experience.

The book is very clearly written and of great scientific value. The subject of shear stresses and the detailing of beams is dealt with very thoroughly. The translation is on the whole well done, though at times a little ambiguous, but the most awkward feature is the notation employed. It is a great pity that the Concrete Institute's Standard Notation was not employed in the English translation, as it would enable the reader to follow the argument so much more readily and intelligibly.

Technical Dictionaries in Six Languages. Vol. VIII. Reinforced Concrete in Sub- and Superstructure. Compiled by Heinrich Becher.

Published by Constable & Co., Ltd., London. Six Shillings net.

Contents.—General Terms.—Fundamental Principles of Mechanics.—Preparation of Concrete.—Treatment of Reinforcing Metal.—Falsework, Casing, Mould Forms. — Foundation. — Masonry. — Floors. — Columns. — Stairs. — Staircases. — Roofs. — Sea and River Work, Waterwork.—Road Making. — Tanks for Liquids. — Bridges. — Artificial Stones. — Silos, Bins.—Alphabetical Index, giving the Page and Column in which each Word is to be found.

The enormous amount of work published in various parts of Europe and America has necessitated the production of a dictionary in English, German, French, Russian, Italian and Spanish, in order that readers acquainted with any of these languages may study accurately the papers written therein. To the ordinary reader of technical articles in a foreign language the usual dictionary is a delusion and a snare, for it either omits the desired word altogether or attaches to it a meaning which is neither accurate nor satisfactory. This is unavoidable in an ordinary dictionary of reasonable dimensions, but it leaves an ample opening for a series of dictionaries in which each special subject is treated in a volume to itself. This is the object of the "Illustrated Technical Dictionaries," of which Vol. VIII. is devoted to the Cement and Concrete industries.

Each volume is written by a number of specialists well acquainted with at least two of the languages used, and in this way the technical accuracy of the whole is assured.

The volume devoted to concrete consists of two main sections, the first of which contains the words arranged in definite groups or subjects, the latter is in simple alphabetical order, so that any word may be found at once, no matter to which language it may belong.

In the first portion of the book each page is divided into three columns; the first contains the English, German and French equivalents, the second contains a small outline sketch of the article (when possible), and the third column contains the Russian, Italian and Spanish equivalents. In this way the article itself may often be found from the illustration even when the precise term for it is unknown. This is particularly the case in Section V., where many forms of scaffolding are shown, and Section IV., which deals with the various systems of reinforcement.

A careful examination shows the great accuracy of the translation in French, German and Italian, and leads one to suppose that the other foreign languages are equally accurately represented. The English portion was chiefly done by Dr. A. B. Searle, of Sheffield.

The Elements of Reinforced Concrete Building. By G. A. T. Middleton, A.R.I.B.A.

Published by Frances Griffiths, London, 1909. Four Shillings net.

Contents.—Rectangular Beams with Supported Ends; Bending Moments.—Resistance Moments.—Designing from Given Data. — Vertical Reinforcements.—T- and L-Beams with Supported Ends.—Continuous Beams.—Beams with Double Reinforcement.—Floor Slabs.—Foundations.—Columns. — Walls and Retaining Walls. — Materials; Mixing and Laying the Concrete.—Falsework, or Centering. — Connections. Some Patent Systems.

The articles which are now put together in book form were first published in *The Building News* to meet the requirements of the rudimentary student, and should be of great use to the beginner as everything is put in a concise and simple form, and the diagrams are very plainly drawn. It is principally intended to clear the ground for further investigation.

The last chapter deals with various patent systems, giving particulars and illustrations of the different appliances used by them.

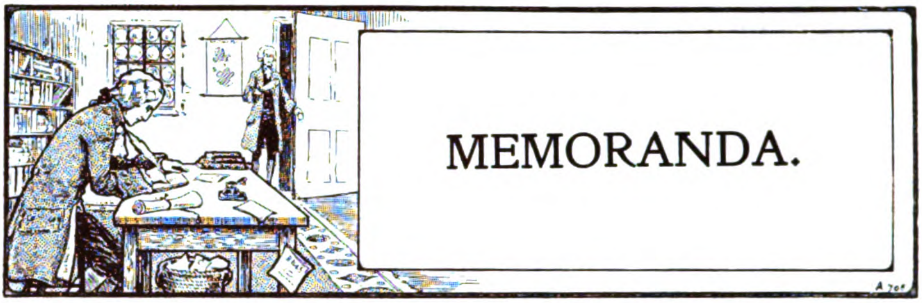
Reinforced Concrete: Theory and Practice. By F. Rings, M.S.A.

Published by B. T. Batsford. Seven Shillings and Sixpence net.

Contents.—Introductory (History of Reinforced Concrete and its Advantages over other Systems of Building).—

Materials (*a*, Portland Cement; *b*, Concrete; *c*, Steel).—Execution of Work (Storing of Materials, Centering, Concreting, Work During Frosty Weather, Striking of Centering, Plastering, Tests).—Loads, Moments, Stresses, and various Applications of Reinforced Concrete (*a*, Floor Slabs; *b*, Ribbed Ceilings; *c*, Stanchions and Columns; *d*, Walls; *e*, Arches, Vaults and Bridges; *f*, Foundations and Piles; *g*, Stairs; *h*, Pipes, Water Mains, Sewers, etc.; *i*, Roofs.—Resistance and Safe Stresses.—Formulæ for Slabs.—Formulæ for Double Reinforced Slabs.—Formulæ for Ribbed Ceilings.—Formulæ for Double Reinforced Ribbed Ceilings.—Shearing Stresses and Adhesion.—Formulæ for Columns Axially and Eccentrically Loaded. — Formulæ for Arches. — Patent Bars and Systems.—Memoranda and Tables.—Index.—Ready Reckoner (in pocket).

This work is intended by the author to deal with the subject of reinforced concrete "in such a manner as to be intelligible to average students of architecture who have not been required to devote that amount of study to the theory of construction which is demanded of the young engineer. At the same time, it is hoped that the present volume may be useful also to the latter." The book does not fail in its aim. It forms a useful introduction to the subject. We should think it somewhat dangerous if it led the architectural student to attempt to design reinforced concrete work for himself, but perhaps the book will serve more to imbue him with an appreciation of the intricacies of the subject and enable him to check the work of contractors, lay down requirements and furnish particulars of assistance to specialists in preparing schemes, and may serve to check that unfair and sometimes unscrupulous competition that results from loose specifications. This book is only an elementary treatise on the subject, but it contains a good deal of valuable information which the author has collected from various sources, particularly Messrs. Tozer's "Handbook," the Associated Portland Cement Manufacturers (1900), Ltd.'s "Everyday Uses of Portland Cement," and Kerstan's "Der Eisenbetonbau." One point in its favour is that it is issued at a small price. Most of the systems and patent bars on the English market are described, and this is a useful feature of the book. The author is the first to adopt the Standard Notation of the Concrete Institute, which we are glad to see, and this example of its application shows that it is a valuable aid to quick understanding by the reader. The remarks of the author on continuity in beams and slabs are commendable, though we think more might with advantage have been said; especially ought the R.I.B.A. Committee's remarks to have been annoted, for they suggest allowance for too small a reverse bending moment over supports. The chapter on shearing stresses is not nearly enough detailed in treatment; this is a very important subject, and we always regret to see new books appear which treat it inadequately. The combination of bent-up rods with separate stirrups in particular is not clear nor is it quite correct. Spirally reinforced columns are not dealt with so far as calculations are concerned—this is a distinctly important omission. The ready reckoner for slabs and rectangular beams given with the book is ingenious, but not of so much value as graphs for practical designing. Aids to the designing of T-beams are not given. We notice an error in giving the weight of a cubic foot of steel on page 149. On the whole the book, if not original in treatment, is of service as an elementary summary of the first principles of the subject.

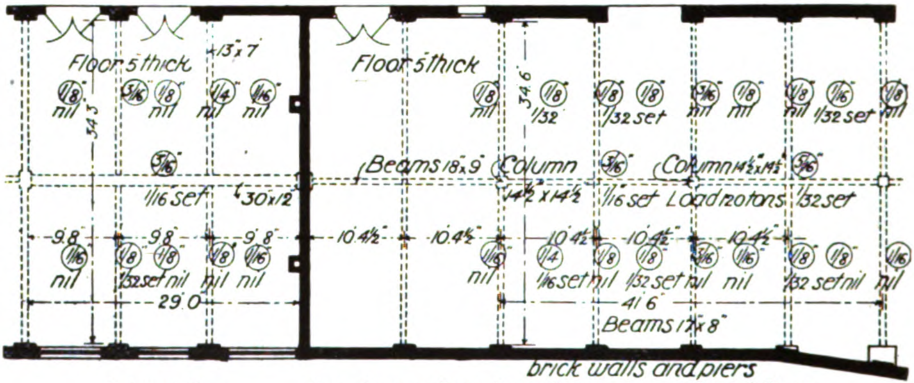


MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

TESTS WITH CONCRETE.

WE have received particulars from Messrs. Stuart's Granolithic Co., Ltd., of an exceptional test carried out on their reinforced concrete floors at the engineers' shops of the L.B. & S.C. Railway, details of which we give below.



Painters' Shop. PART PLAN AT FIRST FLOOR LEVEL. General Stores.

LOADS ON PORTION OF FLOOR ON LEFT OF ILLUSTRATION (PAINTERS' SHOP).

		Per sq. ft.
Weight of Construction	=	·72 cwts.
Weight of Live Load	=	2·50 ,,
Additional Test Load	=	1·25 ,,

TOTAL TEST LOAD OVER AREA OF PAINTERS' SHOP.

29ft. × 34ft. 3in. × 3·75 cwts., = 185 tons (steel rails)

TOTAL LOAD, INCLUDING WEIGHT OF CONSTRUCTION.

29 ft. × 34 ft. 3 in. × 4·47 cwts. = 222 tons

DATES OF TESTING OPERATIONS.

Loading with steel rails commenced	Feb. 12th, 1910
Loading with steel rails completed	Feb. 15th, 1910
Deflections measured from below	Feb. 16th, 1910
Loading removed from floor	Feb. 24th, 1910
Permanent set measured from below	March 5th, 1910

LOADS ON PORTION OF FLOOR ON RIGHT OF ILLUSTRATION (GENERAL STORES).

		Per sq. ft.
Weight of Construction	=	·72 cwts.
Weight of Live Load	=	4·00 ,,
Additional Test Load	=	2·00 ,,

TOTAL TEST LOAD OVER AREA OF GENERAL STORES.

41ft. 6in. × 34ft. 6in. × 6 cwts., = 430 tons (steel rails)

TOTAL LOAD, INCLUDING WEIGHT OF CONSTRUCTION.

41 ft. 6 in. × 34 ft. 6 in. × 6·72 cwts. = 481 tons

DATES OF TESTING OPERATIONS.

Loading with steel rails commenced	Jan. 24th, 1910
Loading with steel rails completed	Feb. 10th, 1910
Deflections measured from below	Feb. 11th, 1910
Load of 185 tons removed from floor	Feb. 12th, 1910
Entire loading removed from floor	Feb. 28th, 1910
Permanent set measured from below	March 5th, 1910

NOTE.—Figures enclosed in circles indicate deflections. Figures below circles indicate permanent set.

Prevention of Dry Rot.—The Council of the Royal Institute of British Architects has issued the following statement of methods of reducing the danger of dry rot in new buildings:—

No timber should be used in such a position that the moisture in and around it cannot be readily evaporated, as, for example, if floors are constructed of solid concrete (with or without steel), wood fillets should not be nailed underneath to receive the ceiling.

No wood slips should be built into or on the top of concrete and afterwards covered with an impervious floor, and no wood boards should be laid direct on the concrete and afterwards covered with an airproof material, such as linoleum or oilcloth.

All ground under a wooden floor should be cleared of any vegetable or fungoid growth and covered with cement, concrete or asphalt, and this should be left as long as possible before any joists or flooring are laid. No wooden pegs communicating with the earth beneath should be left in and through the covering over the earth.

Provision should be made for the abundant introduction of fresh air underneath all parts of the ground floors by means of inlets, and particularly at all angles, so that cross-currents may be induced.

The concrete under floors should be thoroughly cleared of all small pieces of wood and shavings, as it has been found that the spores in these pieces of wood, drawing the moisture from the concrete, have been a means of spreading the disease.

Method for Removing Hair Cracks from Concrete Surfaces.—Mix one part commercial muriatic acid or hydrochloric acid with four parts water; make several applications one after the other, with a brush containing little or no metal. This will not injure the concrete, as the acid does not sink to sufficient depth before it is neutralised. It will eat the surface to possibly the extent of 1-128th of an inch if three applications, within a minute of each other, are applied. The removal of this small portion of the surface will not be noticeable, but is sufficient to remove ordinary hair cracks and crazing, as they seldom go beyond this depth. Within five or ten minutes wash off the surface thoroughly with clean water, scrubbing the surface while washing with an ordinary house scrubbing brush. This will give a surface to the concrete almost as natural and as beautiful as stone.—*The Cement Record.*

Macadam Paving Made with Concrete Cubes.—Road-making on a novel plan is being tried on some of the public roads in the State of New York, by order of the State Highway Commission. The method of construction is the method of Mr. J. Y. McClintock, county engineer of Monroe County, and consists in the use of 2-in. cubes of concrete instead of the usual stone metalling. The cubes are made in a modified form of cement brickmaking machine, 68 cubes being made at each stroke. The tray of cubes removed from the press is placed on a rack and left for 24 hours. The cubes are then thrown upon a heap, which is sprinkled twice daily. A gang of seven men with a foreman can make about 25,000 cubes in a working day. The concrete must be fairly dry or the cubes will settle and bulge before the cement has set. The concrete is made with ½-in. gravel. In surfacing a worn road with this material, a very thin layer of screened gravel was first laid and rolled with a 12-ton roller, giving a finished surface of 16 ft. wide, with a crown of 4 in. and a thickness of ¼ in. to 2 in. The concrete cubes were then laid by hand on a width of 15 ft. with a guide plank at each side. The surface was then covered with a fine loamy gravel, swept into the joints and then slowly rolled by the steam roller to bring the cubes to an even bearing on the gravel beneath. The planks were then removed, gravel was filled in along each side, and more of the fine gravel spread on top, wetted and swept until the interstices were filled, the surface being then given a final rolling. At some places concrete kerbs were built instead of gravel filling at the sides. The final gravel coating—flushed with water—was replaced also in some cases by a grout of Portland cement, and in other cases by an asphaltic road oil sprinkled from a cart.

About 2,600 sq. yds. of road have been covered in this way at an average cost of about 2½d. per sq. yd., but this cost can be reduced by using less cement and substituting concrete-mixing machinery and other devices for the manual labour now employed.—*Engineer.*

Tapering Concrete Chimneys.—The majority of the numerous reinforced concrete chimneys that have been built are cylindrical in shape, due to limitation in the design of the forms, and where a variation in diameter is made this has been effected by an offset. Recently, however, says *Engineering News*, some special designs of form construction have been devised

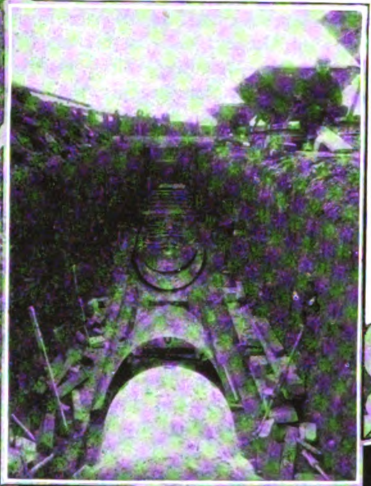
BLAW COLLAPSIBLE STEEL CENTERING

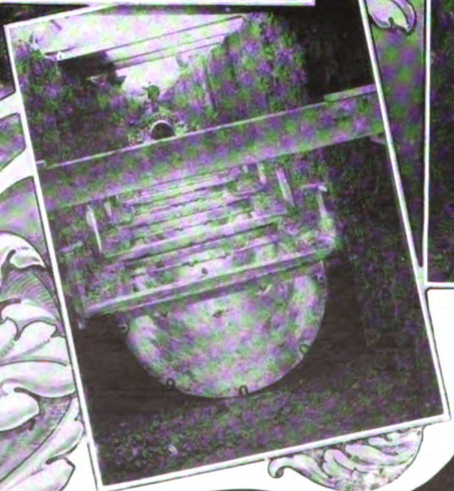
CHEAPER & BETTER THAN TIMBER & MORE EASILY HANDLED & BETTER FINISH ON THE CONCRETE.

FOR SEWERS, CULVERTS, CONDUITS, ARCHES, ROOFS ETC

ILLUSTRATIONS SHOW CENTERS IN USE ON COMBINED BRICK AND CONCRETE CULVERT, FOR THE NORTH-EASTERN RAILWAY CO., AT BLYTH, NORTHUMBERLAND.

THE CONTRACTOR FOR THE WORK WAS MR. T. TELFORD GIBB.





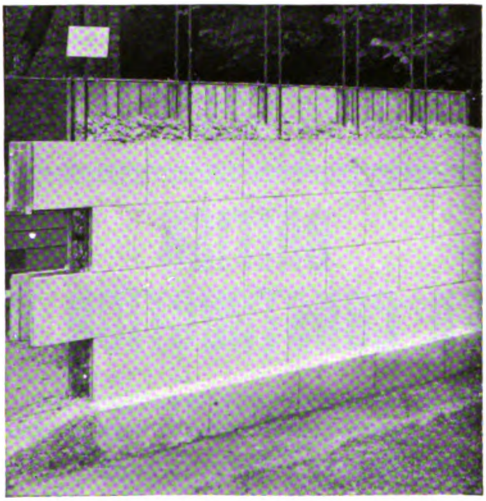
THE BRITISH STEEL PILING COMPANY,

DOCK HOUSE, BILLITER ST LONDON. E.C.

which permit the building of tapering stacks without excessive cost for this feature of the work. The forms, which are 5 ft. high, consist of sets of rings, steel plate forming the surfaces, and long bolts by means of which the adjustments of diameter and wall thickness are made. The rings are of sufficient diameter to enclose the base of the chimney, and are made of heavy angles bent to varying radii and spliced into complete circles. The radial bolts must be long enough to permit of their extending into the chimney surface where the diameter is smallest (at the top of the chimney). The diameter of the rings remains constant, standard sets of form rings being carried in stock for various sizes of chimneys. The steel sheets are of standard size, and are filled out with split sheets, made interchangeable. The sheets are secured by flat-head stove bolts to vertical stiffeners on the outer surfaces of the forms, except at one rib, where the adjustment is taken up. The varying diameter is obtained by means of the long radial bolts which turn through small angles attached to the steel rings and end in malleable clips which grip steel bands on the outside of kerfed wood strips which press the sheets in the desired radius. Permanent centres are kept at the base of the chimney and on the scaffold above, and each section of the chimney is plumbed. Thus perfect alignment is secured throughout the construction.

TRADE NOTICES, CATALOGUES, ETC.

The Apt Reinforced Concrete Walling, Bentley House, St. Mary's Road, Highbury, N., have lately introduced a system of reinforced concrete construction for which many special features of advantage are claimed. Particular attention is called to the fact that the facings forming the centering are anchored to the reinforcing members by transverse ties or bonders, which are slid over the undercut ribs at the back of slabs, gripping both faces and mechanically locking both vertical and horizontal members. As the chief item of cost in reinforced concrete work is in connection with the timber centering, it is pointed out that by the use of the Apt system a considerable saving would be effected, and the necessity for much extra work obviated, as the slabs give a finished surface. As the courses are laid the concrete is filled and tamped down in full view, not bulging or displacing the slabs in any way, a perfectly clear face on either side being provided. The facings may be in glazed ware, fireclay materials, stone, or other building material, and the system is stated to be equally suitable for the construction of sea walls, docks, military works, etc. Any length of tie can be used, and the thickness of the facings and of the concrete filling can vary to meet the requirements of the work in hand. The illustration shown is a photograph of a wall erected on the premises of the Apt Walling Syndicate.



Edmond Coignet, Ltd., have issued a new standard specification for the execution of works in reinforced concrete on their system. The specification should be of interest to our readers as a great deal of care seems to have been given to compiling it, and the various clauses are the result of Messrs. Coignet's experience. The proportions to be used for the mixture of the concrete for different work are given in detail, and we notice the weight of the concrete is given in pounds—224 lb. being equal to one bag of cement; the sand and aggregate are given in parts. This is different from the usual method of stating 1 of cement to 6 of sand and aggregate. For instance, for beams, slabs, columns, and ordinary work Messrs. Coignet specify: one bag of cement (224 lb.), $4\frac{3}{4}$ cu. ft. of sand, $9\frac{1}{2}$ cu. ft. of aggregate. There is also a clause concerning the use of emergency props during tests to prevent any excessive deflections which may be due to bad workmanship or other causes.

Fire at Old Ford at the London Works of Vulcanite, Ltd.—We have received the following memo. from Messrs. Vulcanite, Ltd.: "It has come to our knowledge that in one or two instances since the fire on the 31st March last some roofing contracts have passed us owing to the architect's being prejudiced against Vulcanite Roofing through the fire at our London works.

"As a well-constructed wooden roof covered with our patent Vulcanite Roofing forms an effective fire-resisting roof, as already proved by actual fires and official tests, we wish to remove any misconception that has arisen owing to the fire. The fire broke out in a store and spread through the portion of the works destroyed entirely internally. The failure of the roofs was solely owing to the iron constructional work buckling, causing the structure to give way. A great part of the Vulcanite roofing from the destroyed buildings, found after the fire, had not been damaged at all by fire, and the portion partly consumed was found in places where everything else had perished owing to the fierceness of the fire, which was to a very large extent attributed to the high wind storm blowing at the time.

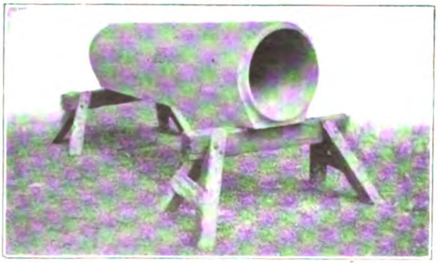
"Where there has been any misunderstanding with regard to this we trust this notice will remove all possible prejudice."

ERRATUM.

Tests at the U. K. Fireproofing Co.'s Works, Alperton.—We regret that owing to an error in transcription the account in our May number of this test gave the load on the floor as 12 tons instead of 72 tons, which made the test appear a poor one, instead of being, in the opinion of all concerned, a very satisfactory one.

"BIC" BRITISH "BIC"
IMPROVED CONSTRUCTION CO., LD.
TELEPHONE: 2531 VICTORIA. TELEGRAMS: "BICONCRETE, LONDON."
47 VICTORIA STREET, WESTMINSTER.

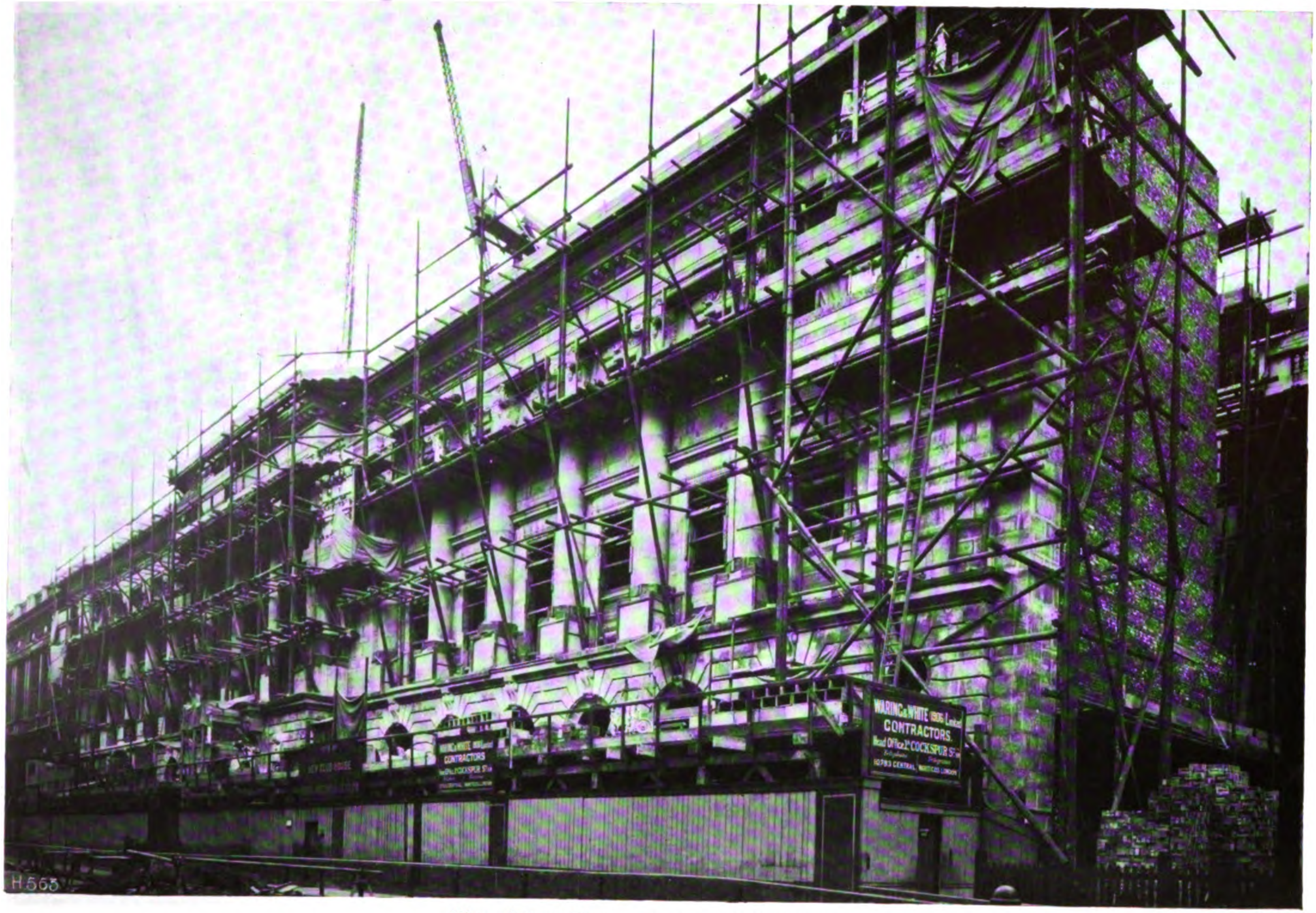
Flat-based Concrete Pipes
Three feet long to Twelve feet long.



Breeze Partitions
Reinforced Sleepers
Telegraph Poles

Porous Pipes
Concrete Beams
Hollow Floors

SPECIALITY:—INVENTORS' DESIGNS CARRIED OUT TO ORDER.



View of Front Elevation in course of Construction.
NEW ROYAL AUTOMOBILE CLUB.

Frontispiece
(Opp. Contents)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 7. LONDON, JULY, 1910.

EDITORIAL NOTES.

CONCRETE IN MINES.

THE terrible death-roll of the Whitehaven colliery disaster appears to have made a strong impression at the Home Office, and Mr. Churchill has promised the miners certain legislative measures with a view of reducing the risk of further calamities of this description.

Attention has been primarily directed to the absence of modern rescue appliances and trained rescue corps, and we fully realize the necessity of prompt measures to remedy the present unfortunate condition of affairs in this direction.

We would, however, point to those in authority that "prevention is better than cure," and that one of the greatest dangers is the mass of timber used in mines for every conceivable purpose. A gradual substitution of concrete and reinforced concrete for timber should be seriously considered, and in all new workings the use of non-combustible materials should be compulsory.

In earlier issues we have pointed to the advantages of using concrete in mines, calling attention to the practical and economical features of the material, and we have presented numerous examples of the application of reinforced concrete pit props, concrete shaft linings, etc.

We trust some effort will now be made to reduce the amount of unnecessary and dangerous timbering in mines, so that the risk of fire in particular may be reduced to a practical minimum.

A SUMMARY OF THE WORLD'S INFORMATION RELATING TO CONCRETE.

WE recently pointed to the useful papers presented by the American National Association of Cement Users, and have published several of them in our columns.

On this occasion we would call attention to the excellent work being done in Canada by the Canadian Cement and Concrete Association in popularising concrete by the presentation of well-considered contributions on the material. In Germany, France, Italy and at home splendid work is being done in the same direction.

The mass of information supplied is, however, becoming cumbersome; at times it is contradictory and all too often inexact. We thus consider that the time has arrived when the " wheat " should be carefully taken from the " chaff," and sifted and summarised by some independent international body, as distinct from any individual.

If the International Commission on Reinforced Concrete could take the matter up it would be invaluable. We throw out the suggestion that a good working sub-committee of that body could do all that is necessary in a year, and have it ready for the next full meeting in 1912.

THE INTERNATIONAL TESTING ASSOCIATION AND PORTLAND CEMENT.

LAST autumn we dealt with the resolutions of the International Testing Association regarding tests of Portland cement, and called attention to a very sensible decision of that body in adopting the Le Chatelier test in particular, regardless of the opposition of the German delegates. The resolution was arrived at at a meeting of some 900 members of the Association, representative of some 22 countries, and on the recommendation of an influential committee. It appears that the German manufacturers have again protested to the Council of the Association as to the Le Chatelier test, but the Council has rightly ignored the protest, and we publish their Minute referring to the matter which speaks for itself :—

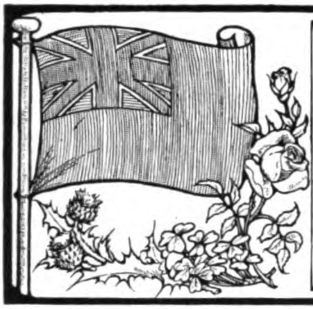
> A protest was lodged by Dr. Müller, in his capacity as chairman of the Association of German Portland Cement Manufacturers, against the recommendation to use M. Le Chatelier's method of testing. It was further pointed out that a fresh point of view had been given to this question by the latest experiments in Zurich.
>
> Thereupon it was agreed to word as follows the motion put before the Fifth Congress with reference to the method in question :
>
> The Fifth Congress—with the reservation of the German members—had decided that the Le Chatelier method was to be recommended as the standard accelerated test for the constancy of volume of cements. It was also decided that the committee be dissolved, but that the problem itself should be retained on the list.

PERMANENT NAVAL DOCKS.

WE had been expecting to hear something definite as to new permanent naval docks to take ships of the *Dreadnought* class, but have not found anything in the debates on the Navy that can be looked upon as at all encouraging.

The recent tendency to order floating docks is an unsatisfactory and expensive makeshift, and the sooner the work on new permanent docks be started the better for the nation.

In any case, we are far behind in meeting the Navy's requirements for dock accommodation, whether in permanent docks or floating docks. Some three years have now been wasted in unnecessary delay, and it is high time that an effort be made to remedy the obvious neglect.



THE NEW ROYAL AUTOMOBILE CLUB.

In our February number we dealt with the foundations and underground work of this building, and in the present article we are describing the constructional steel-work and reinforced concrete floors, which should be of great interest to our readers owing to the importance of the building. Mr. Albert Lakeman, Hon. Medallist Construction and Lecturer at the Woolwich Polytechnic, has prepared these articles for us.—Ed.

CONSTRUCTIONAL STEELWORK AND REINFORCED CONCRETE FLOORS.

THE article on the Automobile Club, which appeared in our February issue, dealt with the underground work, which was of a complicated nature, while in the present one the writer proposes to give some particulars of the superstructure.

There are two floors below the ground floor level, the basement floor being at a level of 28 ft. below this point, which is about 5 ft. above the pavement level, while the intermediate floor, called the lower ground floor, is about 14 ft. 6 in. below the same level. The ground floor line was taken as a datum, and all dimensions are taken from this level.

These lower floors vary slightly in height according to the architectural requirements. There are five floors above the ground floor, the two topmost ones occurring in the roof, and in addition there are small mezzanine floors between the ground and first floors and the first and second floors. One of the principal features of the ground floor is a large elliptical vestibule 48 ft. by 32 ft., which is situated in the centre of the plan, and from this point the main corridors lead to the various rooms. A large restaurant is situated on the east side, 90 ft. by 30 ft. 9 in., exclusive of large recesses, and a similar room on the west side will be occupied as the club room. A large lounge and lecture hall is placed on the south side, this being a very fine apartment measuring 84 ft. by 40 ft., with a height of 32 ft. 6 in., these measurements not including the space occupied by a stage at one end and a gallery situated at the other. All these three large rooms overlook the gardens and park at the rear, and also have access to a large terrace which extends the entire length of the building. In addition there are reception rooms, service rooms, and various other necessary conveniences, as will be seen on the plan of ground floor (*Fig.* 1).

The lower ground floor is chiefly occupied by the elaborate kitchens and offices which give a direct service to the restaurant above, independently of the

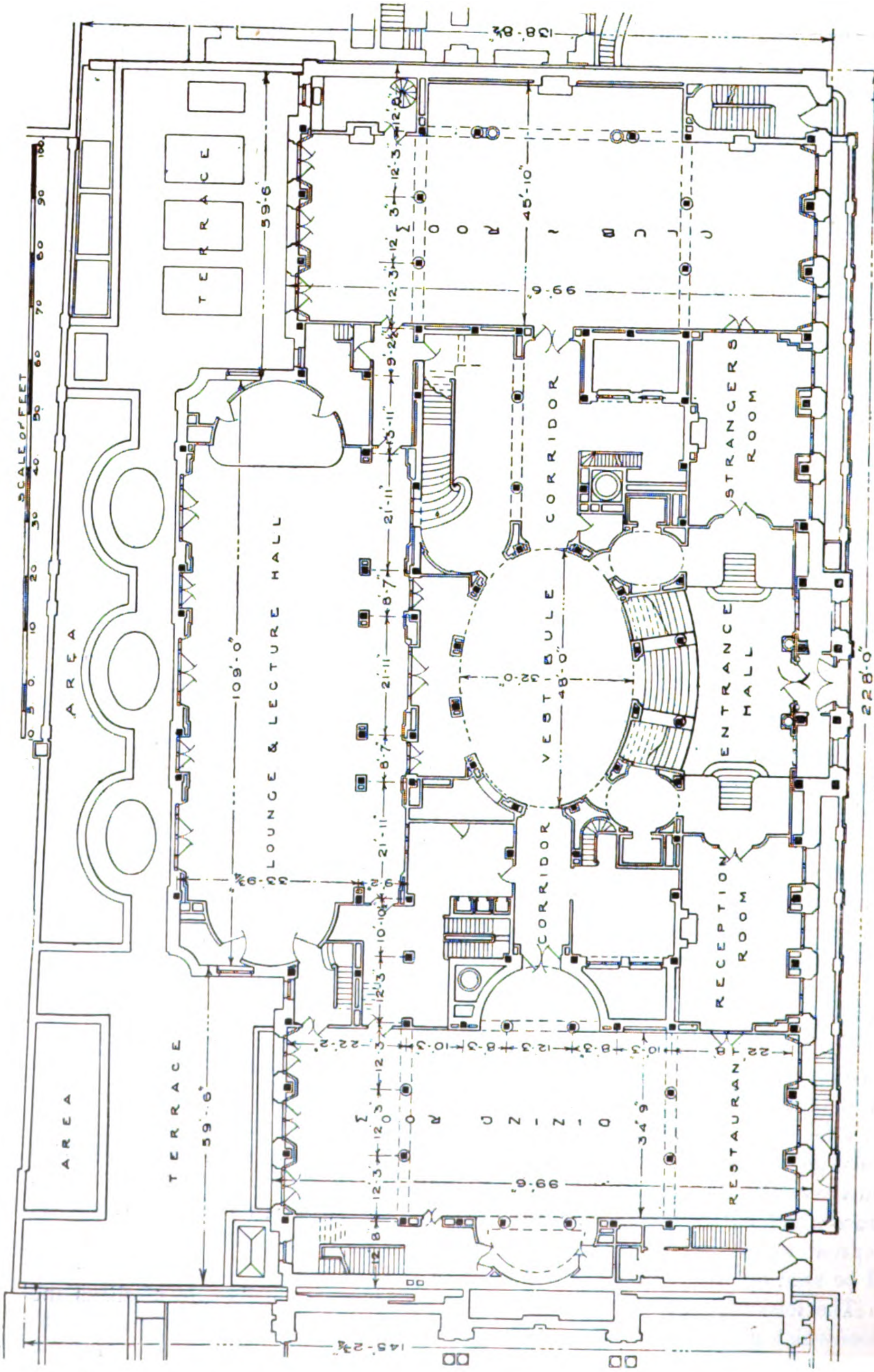


Fig. 1. Plan of ground floor.
New Royal Automobile Club

SECTION AB.

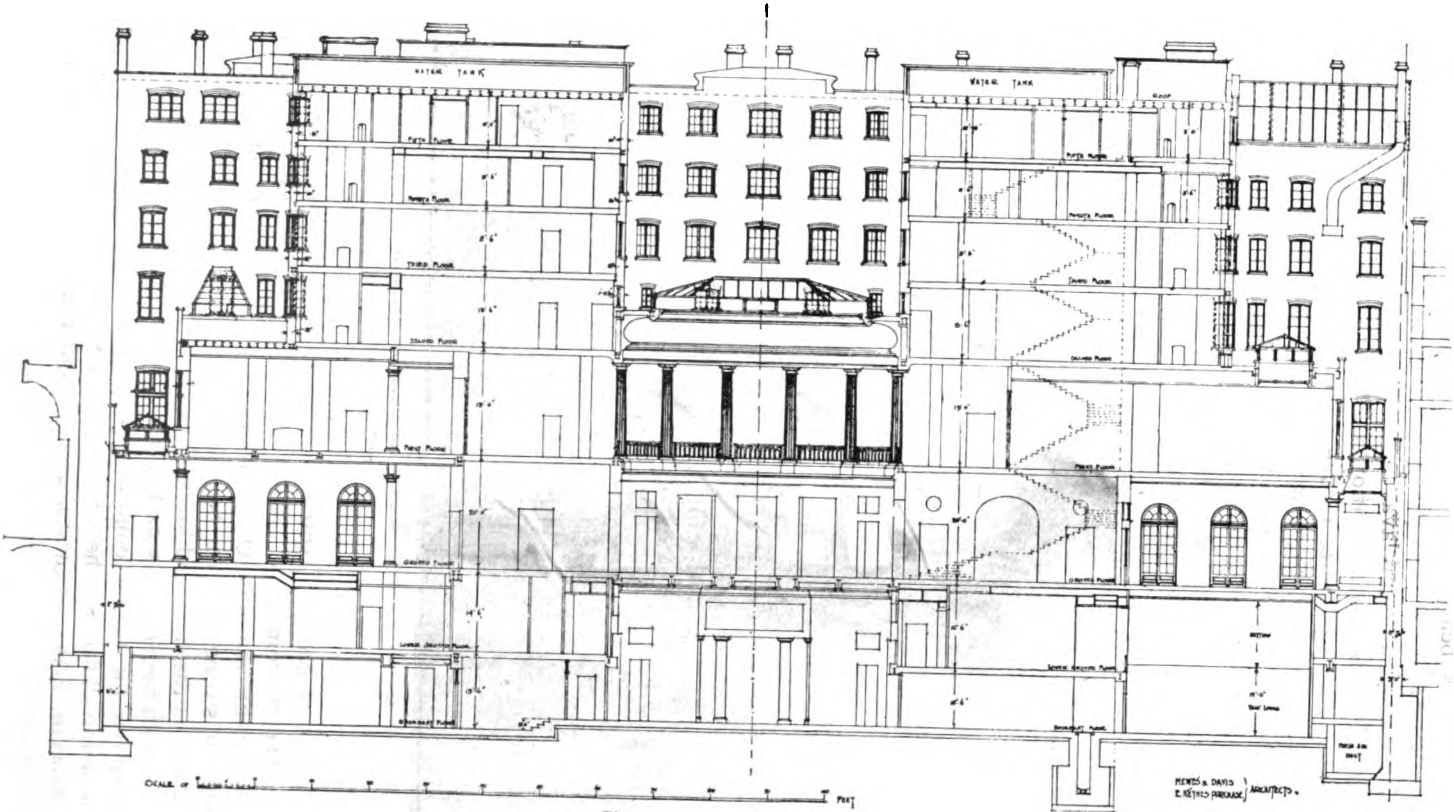


Fig. 2. Longitudinal Section
New Royal Automobile Club

service lifts, this being the most efficient means of obtaining a quick and satisfactory service.

Large cloak rooms and lavatories are also provided on this floor for the use of members, while a large amount of space is given up on account of the swimming bath, gymnasium, and three racquet courts, which are provided in the basement, and which extend through the full height of the two floors with galleries at the lower ground floor level. A Turkish bath is also provided, adjoining the swimming bath, in addition to the accommodation mentioned above, with hairdressers' rooms, dressing rooms, locker rooms, servants' dining hall, boiler room, and even a small shooting range, all on the basement floor.

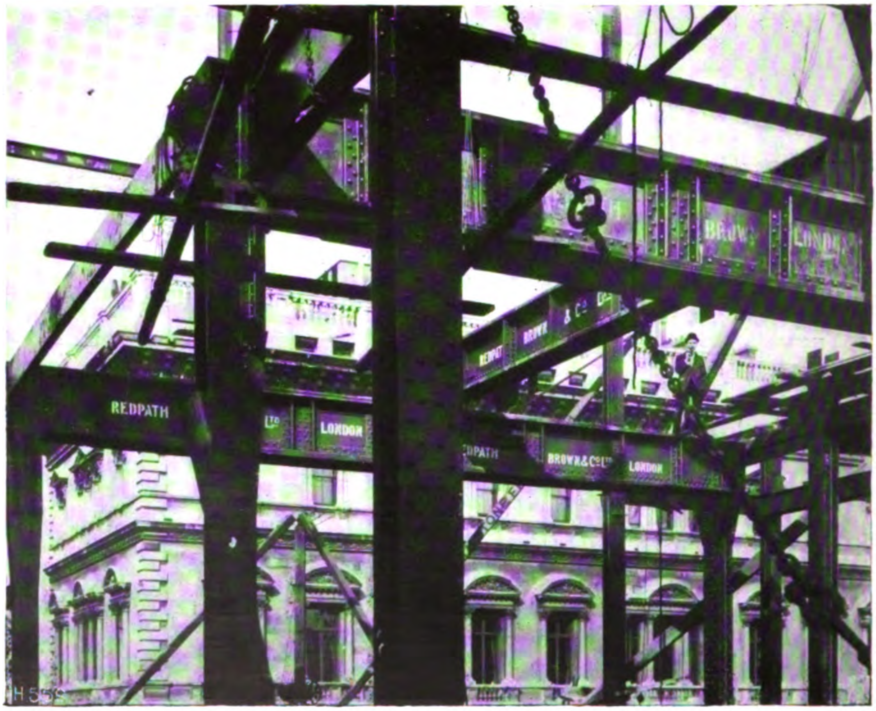


Fig. 3. The largest girder in position.
New Royal Automobile Club.

The first floor is devoted to a large ladies' restaurant, billiard room, card room, library, committee rooms, and various offices; while the second floor is taken up by the touring department and various club offices, with a certain number of sitting, bed, and bath rooms for the use of members. Bedrooms are provided on the third and fourth floors, and the fifth floor is given up to a large studio, with the necessary dark rooms, etc., for photography, and to several large dormitories for the accommodation of the staff. Service stairs and lifts are provided to all floors. The roof level is approximately 84 ft. 6 in. above the ground floor datum, making a total height of about 112 ft. 6 in. from the basement floor level. The whole of the two elevations are built in Portland stone with brick backing, and one of these is shown in *Fig.* 10 during execution.

The building is designed on the skeleton principle up to the first floor level, while above this point a portion of the loads is carried by the external walls, and the interior of the building is carried directly by the steel framing; these external walls themselves, however, are carried by steelwork at the first floor level, and thus the weights are all actually taken down to the foundations by the steel stanchions, the only exceptions being naturally the party walls which assist in carrying a certain amount of the floor loads independently of all steel framing.

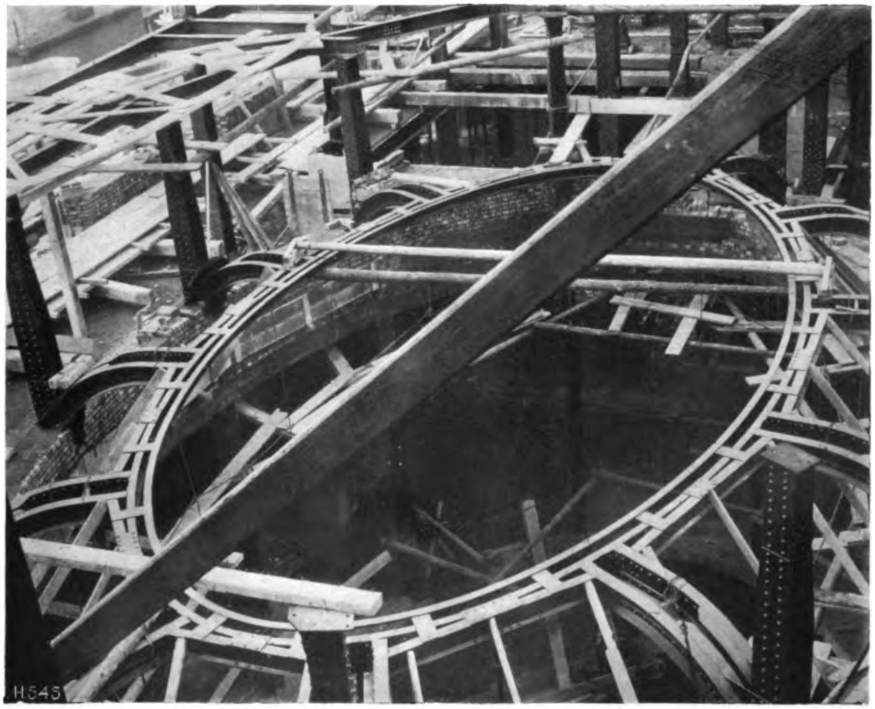


Fig. 4. Framing over central vestibule.
New Royal Automobile Club.

The walls throughout were built of the thickness required under the London Building Act 1894, the designs having been prepared and the work commenced previous to the passing of the L.C.C. General Powers Act 1909, and thus a great deal of unnecessary weight had to be carried at the first floor level by the steelwork supporting very thick walls which would not have been required for purely constructional purposes. Generally speaking, the stanchions are spaced at 12 ft. 3 in. centres along the Pall Mall front, and these bays are carried right through to the rear of the building, except in certain cases where the straight lines could not be maintained owing to the architectural planning.

Steel joists and girders cross these bays, parallel to the front line, at intervals varying from 10 to 30 ft., thus dividing up the framing into a number of rectangular bays with stanchions at each corner. The walls and floors are carried by these main girders, and, generally speaking, no filling-in joists were required, the bays of the floors and roofs throughout being formed in reinforced concrete. Owing to these main beams being of steel only, the floors cannot be considered as consisting of one homogeneous construction, such as occurs where reinforced concrete alone is employed, but rather as a number of bays filled in with reinforced concrete. There are 132 stanchions in all which are carried down to the soil, and the centres for these were set out to $\frac{1}{16}$ in. with a theodolite in order that the steelwork might be prepared, drilled, and riveted as much as possible before leaving the shops, thereby facilitating speedy erection on the site. There are also several stanchions and struts which are carried by steel girders at a higher level. The stanchions which go down to the soil are carried by grillage foundations, this method being considered as the most satisfactory on account of the varying levels which occur, and each grillage is so designed that the pressure per sq. ft. on the soil is absolutely uniform, and thus any unequal settlement is avoided as far as possible, and in addition each grillage is kept entirely free from any adjoining foundation. The stanchion base is bolted to and carried directly by the top layer of grillage beams, which consists of three large rolled steel joists bolted together and stiffened by three rows of cast-iron separators, and with angle stiffeners immediately under the base of the stanchion. The second layer

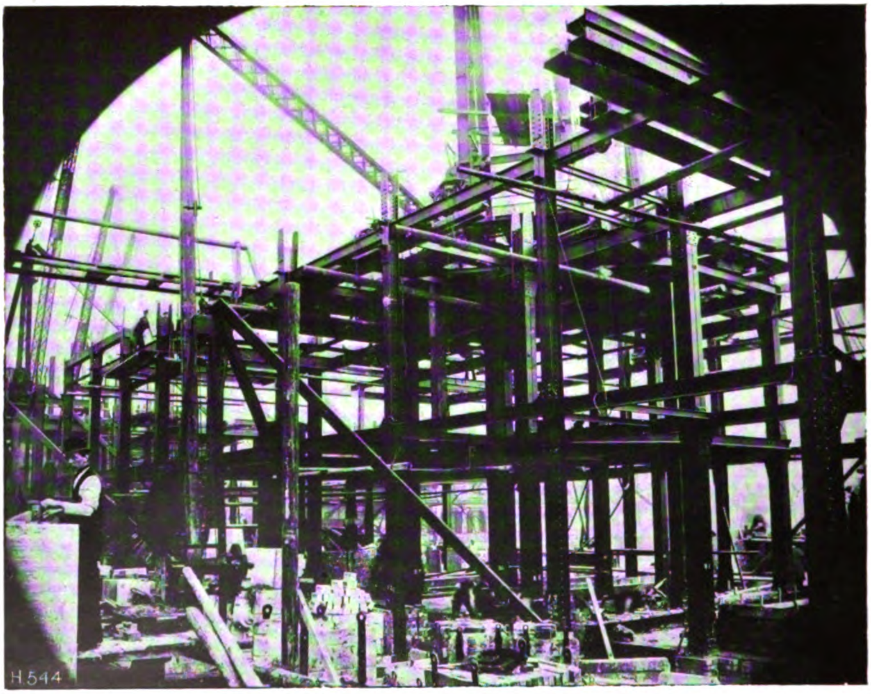


Fig. 5. Steelwork to upper floors.
NEW ROYAL AUTOMOBILE CLUB.

of the grillage consists of smaller rolled steel joists crossing the top layer at right angles, and spaced at about 12-in. centres. These are held together and stiffened by three ¾-in. tie-rods, which pass through the webs with short pieces of gas barrel to keep the joists apart.

Immediately below the second layer of the grillage cement concrete is placed 18 in. thick, and the whole of the steel is enveloped in concrete with a minimum covering of 4 in. at the sides and ends, thus forming a very solid steel and concrete foundation. With the exception of the short minor struts which occur principally in the roof framing, the type of stanchions used was that built up of web plates, four angles and flange plates riveted together with ¾-in. rivets.

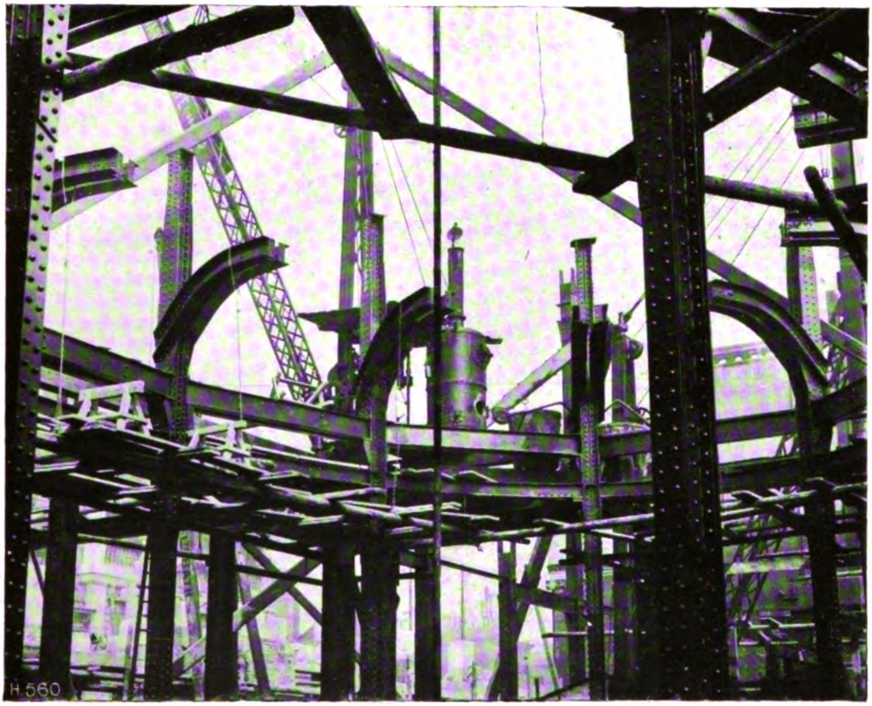


Fig. 6. Framing over central vestibule.
New Royal Automobile Club.

This is an economical form of stanchion, and the largest section employed is built up of one web plate 12 in. by ⅝ in., four angles 6 in. by 6 in. by ⅝ in., and four plates 14 in. by ¾ in., giving an overall size of 15 in. by 14 in. In the design of the stanchions, allowance, of course, was made for eccentric loading wherever necessary, and where no joists or girders occurred at a floor level between two stanchions 4 in. by 2 in. channels were introduced to stiffen the stanchions and reduce the free length.

The type of girder employed varies considerably, according to the position, span, and load to be carried, from a 3-in. by 1½-in. rolled steel joist to the largest girder which is built up of three web plates 30 in. by ¾ in., eight angles 6 in. by

6 in. by ¾ in., six plates 30 in. by ⅝ in., and four plates 30 in. by ½ in., giving an overall size in section of about 3 ft. by 2 ft. 6 in., the total weight of this girder being about 24 tons. The greatest span is about 37 ft., and there are several which are only a trifle shorter. *Fig.* 3 shows this largest girder in position, and there are several others of a similar type. The girders and beams throughout generally were fixed at a level of 4½ in. below the finished floor line to the top flange, this distance giving sufficient space to allow the reinforcement in the floors to pass over the top of the beam with a concrete bedding and flooring above. The beams are generally flange connected to the stanchions, and the load is carried on brackets which are strengthened by stiffeners. Plate girders and beams to beams are web connected, and in addition are supported by brackets where necessary.

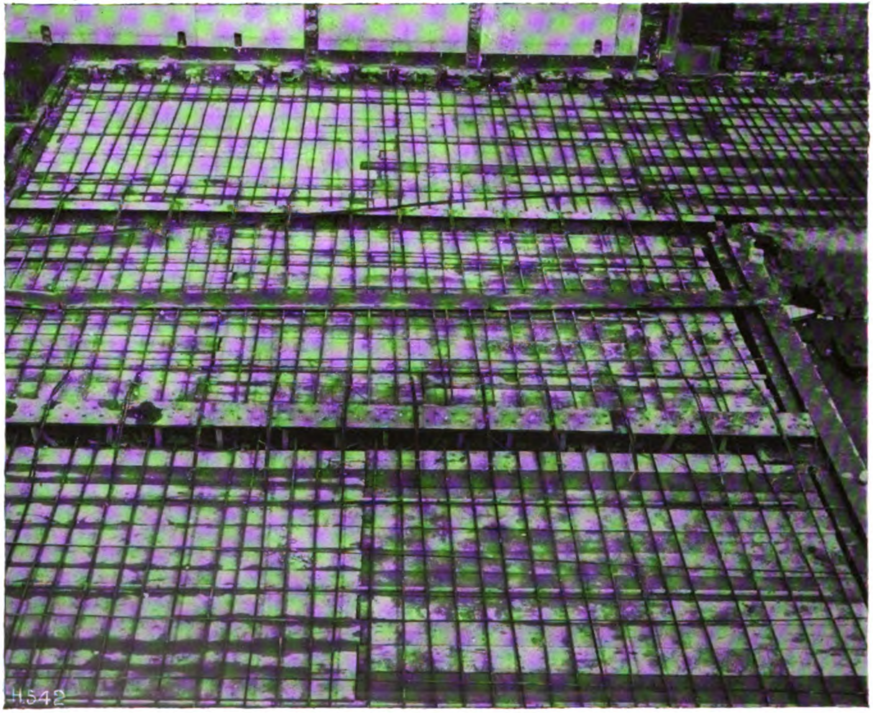


Fig. 7. Reinforcement to floors.
NEW ROYAL AUTOMOBILE CLUB.

A general view of a portion of the steel framing to the upper floors is that shown in *Fig.* 5, and an interesting piece of framing is illustrated in *Figs.* 4 and 6 which show the steelwork over the large elliptical well 48 ft. by 32 ft. which occurs in the centre of the building. This continues up through the first and second floors, with a gallery running round on the inside, and a large open well in the centre, while above these two floors a large skylight occurs with an elliptical ceiling light below, the framing for which is illustrated.

On the upper floors a large elliptical internal court is built, which affords light to the central portion of the building. The architectural treatment imposed many restrictions upon the framing at this point and at the first floor level generally, and these had to be overcome by very careful design on the part of the consulting engineer. Where two or more steel joists are placed together, they are bolted and separated by cast-iron separators, and all beams over 5 in. deep resting on walls are carried by metal wall plates. The size of the rivets used throughout generally is $\frac{3}{4}$ in. diameter, with a pitch not exceeding 6 in., nor sixteen times the thickness of the thinnest outside plate nor less than three times the diameter of the rivet. The holes for the rivets were drilled, and hydraulic riveting was used where possible, while the safe loads in lb. per sq. in.

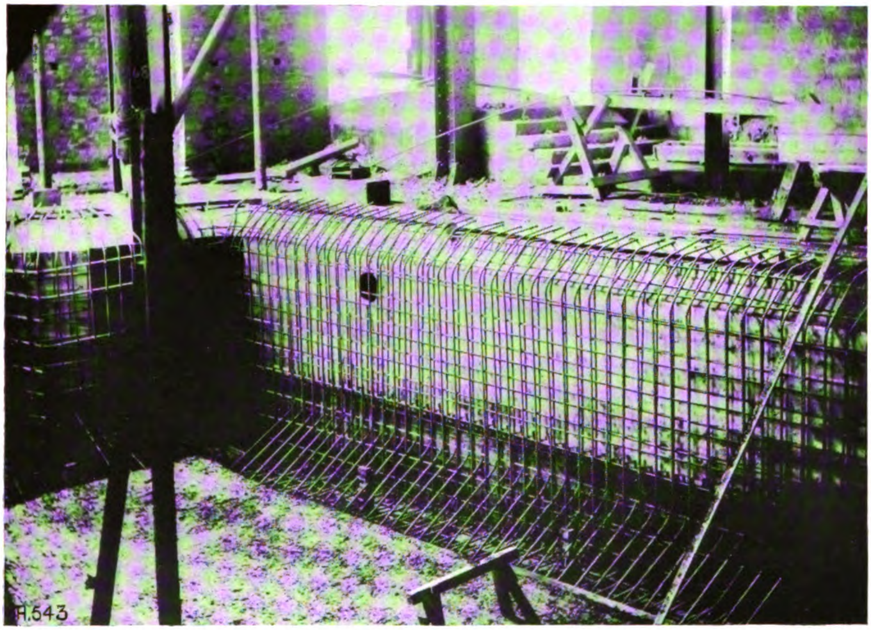


Fig. 8. Swimming bath, showing reinforcement to sides.
New Royal Automobile Club.

that were taken in calculating the connections are as follows: Tension, 16,000; compression, 16,000; shear, 10,000; bearing, 20,000; and bending, 16,000. The medium steel used for the stanchions and beams was required to have an ultimate strength of from 60,000 to 70,000 lb. per sq. in., with an elastic limit not less than half the ultimate strength. The test pieces were required to give an elongation of not less than 22 per cent. in a length of 8 in., and for the bending test were required to withstand bending 180° over a bar having a diameter equal in thickness to the piece tested, without fracture on the outside of the bent portion. The soft steel used for rivets was required to have an ultimate strength of from 48,000 to 50,000 lbs. per sq. in., with an elastic limit not less than half this amount. The elongation required was 26 per cent. in a length of 8 in., and the bending test imposed was that of a bend of 180° flat on itself without fracture on the outside of the bent portion. Foreign steel, excepting Belgian, was permitted, and the whole of the material was inspected during manufacture at the different stages, and also during the process of building up in the shops by Messrs. Robert Hunt & Co., without whose approval as regards quality and workmanship no material was allowed to be delivered on the site. All members, when finished, were painted with a coat of red oxide and pure linseed oil, and the entire steelwork, after erection and riveting, was painted with two coats of best quality Dixon's silica graphite paint.

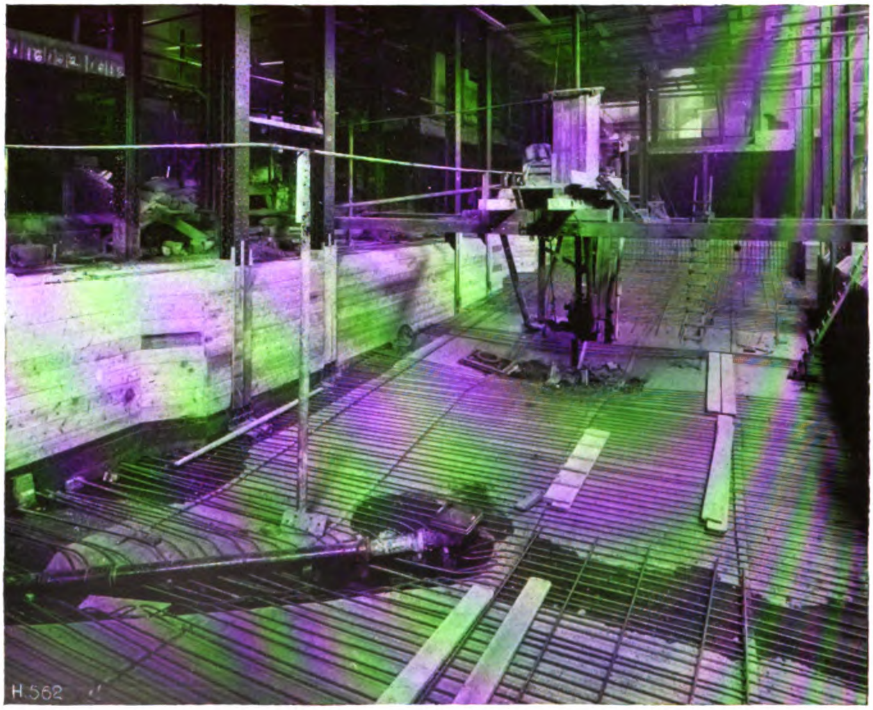


Fig. 9. Reinforcement of floor of swimming bath.
NEW ROYAL AUTOMOBILE CLUB.

The floors and roofs, as previously mentioned, were constructed of reinforced concrete, and *Fig.* 7 shows the reinforcement and centering for a portion of one floor in position previous to the filling in of the concrete. The span of these floors varies from 8 ft. to 14 ft., and the bars, generally speaking, were placed at 6-in. centres, while the thickness of the concrete employed varied from 4½ in. to 7 in. The top of the concrete was worked to a level of 3½ in. below the finished floor line, and as the steel girders were fixed at a level of 4½ in. below the same point, a covering of 1 in. was obtained over the top flanges, and this allowed a certain amount of the reinforcement to be carried over the girders and into the adjoining panels. As a general rule, every third bar was bent up, as shown in the photograph, and a long splice formed with the corresponding bar in the adjoining bay, and this provided sufficient reinforcement to resist the shearing stress at the supports, and also prevented the concrete from cracking over the flange of the girder. Where the floor occurred on one side of the girder only the bars were bent up and well cranked over the top flange, thus achieving the same object. Reinforcement was also provided at right angles to the main reinforcing bars to form a tie and distribute the temperature stresses, which might cause cracks, and this consisted of ⅓-in. square bars at 2-ft. centres.

The lower portions of the steel beams are protected by concrete casing, which in the large girders was cast in position, but in the case of rolled steel joists special concrete blocks were used, which fitted round the bottom flange, and which were secured by wire clips bent up and over the top flange, the latter being entirely enveloped with concrete when the reinforced floors were constructed, thus saving a large amount of time and labour, which would have been necessary in making the various forms. The type of reinforcement employed was that of a deformed bar, which allowed a high carbon steel to be used with great tensile strength on account of the mechanical bond between the steel and the concrete, which distribute any stress to every part. The bars used are the patent indented steel bars of ½ in. and ⅓ in. section, and the tests imposed were sufficiently severe to guarantee that there was no brittle tendency, as this fault is liable to occur with high carbon steel. The ground and lower floors were calculated to carry a load of 220 lb. per sq. ft., and the upper floors and flat roofs a load of 160 lb. per sq. ft.

The concrete was composed of 1 part Portland cement, 2 parts sand, 2 parts clinker, and 2 parts ballast, and the whole was mixed by machinery. The cement was required to comply with the British Standard Specification for medium-setting cement, the only variation being that the tensile strength required was to be at least 600 lb. per sq. in. after 28 days' setting, instead of 500 lb. as called for in the British standard. The sand contained a mixture of fine and coarse sand, and was screened to pass a 3/16-in. mesh, and this was mixed with the cement in the dry state before the addition of the coarse aggregate. The gravel was crushed and screened to pass a ¾-in. diameter ring, and the clinker was broken to the same state, and was free from all coal, coke breeze, or ashes. A specially erected machine was employed for the complete operations of crushing, screening, gauging, and mixing, and all the preparation was accomplished at this one point under efficient supervision, the concrete being immediately despatched to the various parts of the works as required, and in no case was more than half an hour allowed to elapse between the time of mixing and the time of placing in position.

Where holes were required for pipes or similar purposes care was taken to strengthen the floors at these points, and where the holes were very large proper steel framing was provided. Where new work was placed next to the surface of concrete that had been allowed to harden, the latter was thoroughly cleaned of all dust and loose particles and given a thick coat of neat cement grout before the new concrete was deposited. Owing to the various projections which occurred below the floors, such as girders of different sizes, ventilation ducts, pipes, and cables running in different directions, it became necessary to form special suspended ceilings in many of the rooms and corridors in order to obtain a satisfactory ceiling line. These were constructed of special pumice concrete slabs 2½ in. thick suspended from the girders and concrete floors above, with steel hangers at intervals, which carried inverted steel tees at their lower ends, on which the slabs rest, wire lathing being provided to give a key for the plaster on the underside of these steel tees. In addition to giving a flush ceiling which could be treated as required, these slabs form an excellent protection for the pipes, etc., above in case of fire.

The work to the swimming bath affords an interesting example of reinforced concrete construction, which admirably demonstrates the adaptability of this material where strength and reliability are the primary considerations. This bath is situated in the basement floor on the south side, and its size is 86 ft. 9 in. by 30 ft. 8 in., these measurements being to the face of the concrete work only. The depth varies from 4 ft. 4 in. at the shallowest point to 8 ft. 10 in. at the deepest, the latter being situated at a distance of 18 ft. from the diving end, where the depth is only 7 ft. 4 in. Thus there are two slopes in the bottom of the bath, falling from either end to the deepest part, where the outlet is placed, and this gives the bather the greatest depth of water at the point required when diving from the highest stage. A subway is constructed on all four sides immediately on the outside of the bath, and owing to the numerous grillages and other underground work in the immediate vicinity the space that could be utilised for this purpose was limited, and consequently it was necessary to keep the wall of the bath as thin as possible. This subway also rendered it impossible for the wall to receive any assistance on the outside, and, in addition, made it necessary for same to carry a portion of the floor around the bath which comes over the subway. Had any material other than reinforced concrete been adopted the walls would necessarily have been so thick that the space available for the subway would have been reduced to such an extent as to render it useless. Another point which greatly governed the design of the construction was the necessity of keeping the bath entirely free from all surrounding stanchions and grillages to prevent any slight settlement which might occur with the latter from affecting the former. There are twelve stanchions, which run down close to the walls of the bath, and as these are only 33 ft. 9¼ in. centre to centre across the bath, and the width of the latter inside the concrete work is 30 ft. 8 in., it will be seen that the wall in front of the stanchions was limited in thickness.

There are four flights of steps leading down into the bath from the floor level, these being formed in plain concrete in recesses formed in the reinforced walls, giving a straight line on the inside of the bath and preventing any obstructions. All the corners of the bath were splayed, and the concrete was also splayed off at the top. The space for the subway and bath was firstly prepared, and the asphalt damp course, which passes under the entire building, was completed in every respect, and then the concrete work was commenced. The thickness of the reinforced work is 18 in. for the bottom of the bath and 12 in.

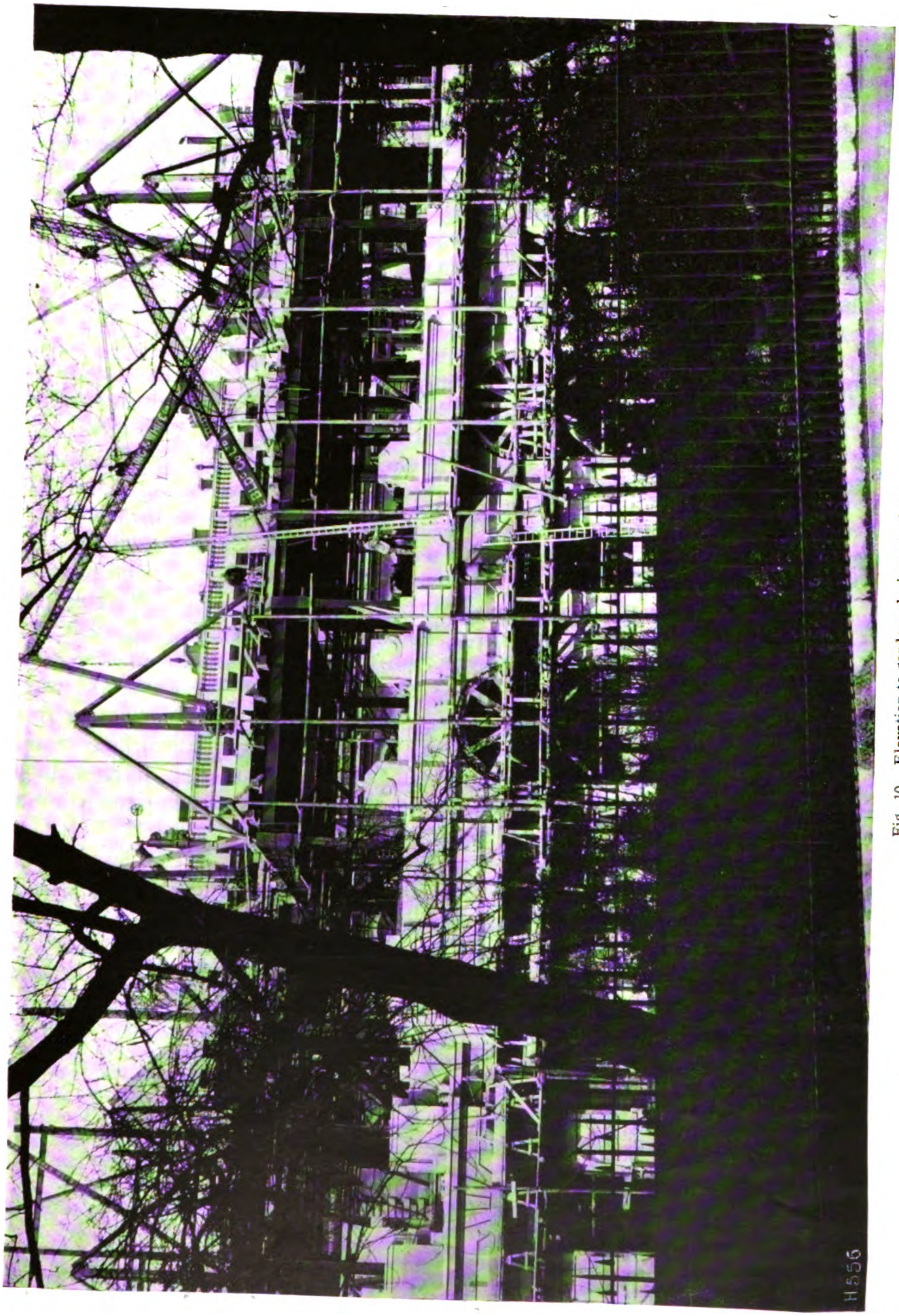


Fig. 10. Elevation to gardens during erection.
NEW ROYAL AUTOMOBILE CLUB.

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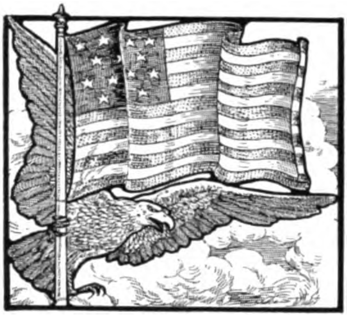
for the side and end walls. The bottom of the bath was formed with a dip or trench at the deepest point to allow the waste pipe for emptying purposes to pass over the reinforced work and the damp course and avoid making an opening in the two latter, which would have been a source of weakness. After the waste pipe and outlet were in position the work was brought to the required level with plain concrete filling. The reinforcement to the bottom consisted of ⅝-in. square indented steel bars spaced at 6-in. centres across the width of the bath, with similar bars placed longitudinally at 12-in. centres. These bars were placed in both the top and bottom surface of the concrete. The walls were reinforced with vertical bars ½ in. square spaced at 6-in. centres, with similar bars placed horizontally at 9-in. centres, these being also put in both the inner and outer surfaces of the concrete. The splayed portions were additionally reinforced by shaped bars, as will be seen in the photograph (*Fig.* 8), which shows a portion of the reinforcement at the deep end with some of the concrete filled in, while the reinforcement to the bottom of the bath is illustrated in *Fig.* 9. All the bars were wired together at every crossing to obviate any displacement when filling in the concrete, and this entailed about 20,000 wirings. The total weight of the reinforcement was about 40 tons. The concrete was composed of 1 part Portland cement, 2 parts sand, and 4 parts of ballast, and the lower layer of bars was concreted in the first instance, and then 1 ft. of the sides, returning again to the bottom, when the second layer was encased. After this the sides were completed, and during the whole time occupied in the execution the concrete in position was well watered night and day in order to ensure the whole of the work being in one solid mass. When the concrete work was complete a layer of asphalt was applied over the whole of the inner surface of the bath to prevent any water from percolating from the latter, and the bath when finished will be lined with white Sicilian marble 1½ in. thick laid in slabs 3 ft. wide and the full depth of the bath without horizontal joints. The steps leading down into the water and the paving around the bath will be finished with similar material.

As mentioned in our previous article, the architects for this building are Messrs. Mewes & Davis and Mr. E. Keynes Purchase, while Mr. S. Bylander acted as Consulting Engineer to the Architects.

The cement used was the "Hilton Anderson" brand of the Associated Portland Cement Manufacturers (1900) Ltd. The structural steelwork was carried out by Messrs. Redpath, Brown & Co., and the reinforcement was that of the Patent Indented Steel Bar Co., Ltd.



REPORT OF COMMITTEE ON REINFORCED CONCRETE.

ISSUED BY THE AMERICAN NATIONAL ASSOCIATION OF CEMENT USERS.

At a time when there is so much discussion as to suitable rules, it is useful to know the views put forward in other countries as to the value of reinforced concrete, and to know the safeguards advocated is also of importance.

Thus we present the American Report recently issued on the subject, which we consider to be a very practical one.—ED.

1. THE recommendations in this report conform in general to the more complete report of the Joint Committee on Concrete and Reinforced Concrete representing the American Society of Civil Engineers, the American Society for Testing Materials, the American Railway Engineering and Maintenance of Way Association and the Association of American Portland Cement Manufacturers. The same unit stresses are suggested and the formulas are based on these unit stresses using methods of computation advised by the Joint Committee.

USES.

2. Concrete, plain and reinforced, is recognised as an established material for construction. Because of its fire-resisting qualities, strength in compression, and relatively low cost, concrete is adapted not only to structures where stresses are principally compressive, such as foundations, dams, retaining walls and other walls, piers, abutments, short columns and arches, but with the use of metal reinforcement properly placed it is also available for a variety of structures and structural forms where both compression and tension exist, as in beams and slabs.

RESISTANCE TO EXTERNAL AGENCIES.

3. ***Fire Resistance.***—Concrete is incombustible and resists the action of ordinary fires, so that it may be safely used for fireproofing purposes. The thickness of the protective coating required depends upon the probable duration of a fire which is likely to occur in a structure. For ordinary conditions it is recommended that the metal in girders and columns be protected by a minimum of 2 inches of concrete, that the metal in beams be protected by a minimum of 1½ inches of concrete, and that the metal in floor slabs be protected by a minimum of 1 inch of concrete. In monolithic concrete columns the concrete to a depth of 1½ inches may be considered as a protective covering and not included in the effective section when computing the strength.

4. ***Watertightness.*** — When proportioned to attain greatest density, not leaner than one part cement to two parts fine aggregate, to four parts coarse aggregate, and mixed to a rather wet consistency, concrete is impervious under ordinary conditions. Long walls to resist water pressure must be effectively reinforced to prevent cracks due to temperature contraction or shrinkage, or must be waterproofed by asphaltic or similar preparation, or the length may be broken by vertical construction joints sealed by metal flashing.

5. ***Corrosion of Metal Reinforcement.***—Steel embedded in good, dense concrete will not corrode under ordinary conditions, whether located above or below fresh or sea water level. On the other hand, if concrete is porous, it may permit moisture to penetrate and corrode the metal.

6. ***Sea Water.***—To best resist sea water, concrete must be proportioned to secure maximum density and mixed thoroughly to obtain impervious concrete.

7. ***Acids.*** —Concrete of first-class quality thoroughly hardened is affected appreciably only by strong acids which seriously injure other materials. A substance like manure, because of the acid in its composition, is injurious to green concrete, but after the concrete has thoroughly hardened it satisfactorily resists such action.

8. ***Oils.*** — When concrete is properly made and the surface carefully finished and hardened, it resists the action of such oils as petroleum and ordinary engine oils. Certain oils which contain fatty acids appear to produce injurious effects.

9. ***Alkalies.*** — In the arid regions alkaline ground water in some cases has been known to injure concrete and most other structural materials. For use under such conditions concrete should be especially rich, dense and impervious.

RESPONSIBILITY AND SUPERVISION.

10. The users of cement will recognise the great difference in both design and construction between plain concrete work such as sidewalks, roads, foundations, heavy mass work, etc., and reinforced concrete structures. Plain concrete serves the requirements admirably for work where tensile stresses do not occur to any extent. In reinforced concrete structures steel must be added to the concrete to make a safe structure, and the proper sizes, dimensions and arrangement of concrete and steel to obtain safety, strength and durability require the knowledge and experience of the engineer. Many of our failures in reinforced concrete construction are the result of improper or inadequate design, and many others are due to incompetent supervision.

11. It is, therefore, strongly recommended that all structures to be built of reinforced concrete shall be designed by experienced reinforced concrete engineers, and that the drawings to be furnshed to the builder shall show clearly and in detail the sizes and dimensions of all parts of the structure, the lengths of all steel reinforcement and its exact position with respect to the concrete members, and that these drawings shall be accompanied by specifications giving the quality of the materials to be used, the proportions of the concrete and the character of the workmanship.

12. It is also strongly recommended that the character of the supervision given to reinforced concrete structures be improved. Such supervision as is customary in the building trades is not sufficient to attain either successful or economical construction in reinforced concrete.

13. All reinforced concrete work should be under the constant direction of experienced reinforced concrete superintendents—preferably men having a knowledge of engineering.

CEMENT.

14. Only Portland cement is suitable for reinforced concrete construction or for any construction that will be subject to shocks or vibrations or stresses other than direct compression.

15. The cement should meet the requirement of the Standard Specifications for cement as adopted by the American Society for Testing Materials.

AGGREGATES.

16. ***Fine Aggregates.***—Fine aggregate consists of sand, crushed stone or gravel screenings passing when dry a screen having ¼-in. diameter holes or a screen having four meshes to the linear inch. It should be preferably of silicious material, clean, coarse, and free from vegetable loam and other deleterious matter.

17. It is impossible to positively determine the quality of a sand by inspection. Frequently a sand containing a very small percentage of silt may have its grains coated with organic or other matter so as to dangerously retard the setting of the concrete; consequently the testing of the sand is fully as important as the testing of the cement.

18. Mortars composed of one part Portland cement and three parts fine aggregate by weight when made into briquets should show a tensile strength of at least 70 per cent. of the strength of 1 : 3 mortar of the same consistency made with the same cement and standard Ottawa sand. To avoid the removal of any coating on the grains which may affect the strength, bank sands should not be dried before being made into mortar but should contain natural moisture. The percentage of moisture may be determined upon a separate sample for correcting weight. From 10 to 40 per cent. more water may be required in mixing bank or artificial sands than for standard Ottawa sand to produce the same consistency.

19. The relative strength of mortars from different sands is largely affected by the size of the grains. A coarse sand gives a stronger mortar than a fine one, and generally a gradation of grains from fine to coarse is advantageous. If a sand is so fine that more than 10 per cent. of the total dry weight passes a No. 100 sieve, that is, a sieve having 100 meshes to the linear inch, or if more than 35 per cent. of

the total dry weight passes a sieve having 50 meshes per linear inch, it should be rejected or used with a large excess of cement.

20. For the purpose of comparing the quality of different sands a test of the mechanical analysis or granulometric composition is recommended, although this should not be substituted for the strength test. The percentages of the total weight passing each sieve should be recorded. For this test the following sieves are recommended :*

0.250 inch diameter holes.†					
No. 8 mesh,	holes	0.0055	inch width	No. 23	wire.
No. 20 ,,	,,	0.0335	,, ,,	No. 28	,,
No. 50 ,,	,,	0.0110	,, ,,	No. 35	,,
No. 100 ,,	,,	0.0055	,, ,,	No. 40	,,

21. The effect of mechanical analysis or granulometric composition upon the strength of mortar is illustrated in Appendix. By this table the relative strength of different sands may be approximately estimated.

22. ***Coarse Aggregates.***—Coarse aggregate consists of inert material such as crushed stone, or gravel, which is retained on a screen having ¼-in. diameter holes. The particles should be clean, hard, durable, and free from all deleterious material. Aggregates containing soft, flat or elongated particles, should be excluded from important structures. A gradation of sizes of the particles is generally advantageous.

23. The maximum size of the coarse aggregate should be such that it will not separate from the mortar in laying and wiii not prevent the concrete fully surrounding the reinforcement or filling all parts of the forms. Where concrete is used in mass the size of the coarse aggregate may be such as to pass a 3-in. ring. For reinforced concrete a size to pass a 1-in. ring or a smaller size may be used.

24. Cinder concrete is not suitable for reinforced concrete structures, and may be safely used only in mass for very light loads or for fireproofing.

25. Where cinder concrete is permissible, the cinders used as the coarse aggregate should be composed of hard, clean, vitreous clinker, free from sulphides, unburned coal, or ashes.

WATER.

26. The water used in mixing concrete should be free from oil, acid, strong alkalies, or vegetable matter.

METAL REINFORCEMENT.

27. The Committee recommends that mild steel such as fills the specifications for structural steel of the American Railway Engineering and Maintenance of Way Association is a suitable material.

28. If steel of higher elastic limit is used, it must be of first-class quality and subjected to special tests even if used at the same working stress as mild steel. It should be required to pass the following test :

29. Test specimens for bending shall be bent cold under the following conditions without fracture on the outside of the bent portion :

Around twice their own diameter : 1-in. diameter 80 deg.; ¾-in. diameter 90 deg.; ½-in. diameter 110 deg.

Around their own diameter : ¼-in. diameter 130 deg.; $\frac{3}{16}$-in. diameter 140 deg.; ⅛-in. diameter or less 180 deg.

The reinforcement should be free from rust, scale or coatings of any character which would tend to reduce or destroy the bond.

PROPORTIONS.

30. The materials to be used in concrete should be carefully selected, of uniform quality, and proportioned with a view to securing as nearly as possible a maximum density.

31. The unit of measure should be the barrel, which should be taken as containing 3.8 cub. ft. Four bags containing 94 pounds of cement each should be considered the equivalent of one barrel. Fine and coarse aggregate should be measured separately as loosely thrown into the measuring receptacle.

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* Sheet brass perforated with round holes passes the material more quickly than square holes. Round holes corresponding to sieves No. 8, 20 and 50 respectively are approximately 0.125, 0.050, 0.020 inch diameter.

† A No. 4 sieve, having 4 meshes per linear inch, passes approximately the same size grains as a sieve with 0.25 diameter holes.

32. If the coarse aggregate contains sand or other fine material, that which passes a sieve with ¼-in. round holes should be considered as sand in measuring proportions. In general, the concrete on the work should contain enough and only enough mortar to cover all particles of stone and fill the voids without an appreciable excess of mortar.

33. The proportions of cement to sand and stone should be chosen after a very careful study of the local conditions and the available materials. For small and unimportant structures the following list is presented to be used as a rough guide to the selection of proportions for different classes of work. The relative proportions of fine to coarse aggregate may be varied to suit the materials:

(a) A *Rich Mixture* for columns and other structural parts subjected to high stresses or requiring exceptional water-tightness: Proportions 1 : 1½ : 3; that is, one barrel (4 bags) packed Portland cement to 1½ barrels (5·7 cub. ft.) loose sand to 3 barrels (11·4 cub. ft.) loose gravel or broken stone.

(b) A *Standard Mixture* for reinforced floors, beams and columns, for arches, for reinforced engine or machine foundations subject to vibrations, for tanks, sewers, conduits, and other water-tight work: Proportions 1 : 2 : 4; that is, one barrel (4 bags) packed Portland cement to 2 bags (7·6 cub. ft.) loose sand to 4 barrels (15·2 cub. ft.) loose gravel or broken stone.

(c) A *Medium Mixture* for ordinary machine foundations, retaining walls, abutments, piers, thin foundation walls, building walls, ordinary floors, sidewalks, and sewers with heavy walls: Proportions 1 : 2½ : 5; that is, one barrel (4 bags) packed Portland cement to 2½ barrels (9·5 cub. ft.) loose sand to 5 barrels (19 cub. ft.) loose gravel or broken stone.

(d) A *Lean Mixture* for unimportant work in masses, for heavy walls, for large foundations supporting a stationary load, and for backing for stone masonry: Proportions 1 : 3 : 6; that is, one barrel (4 bags) packed Portland cement to 3 barrels (11·4 cub. ft.) loose sand to 6 barrels (22·8 cub. ft.) loose gravel or broken stone.

MIXING OF CONCRETE.

34. Methods should be devised to always make positive the proper proportioning and therefore the accurate measuring of the concrete materials, including water. Accurate measurements are of the greatest importance.

35. The concrete materials should be mixed until the cement is uniformly distributed throughout the mass and the concrete therefore uniform in colour and homogeneous. Sufficient water must be added during the mixing to produce a concrete that will flow when agitated, but not so wet as to permit a separation of the materials in transferring from mixer to the work. Mixing by machine should always be preferred, since the most thorough and uniform consistency can be thus obtained.

36. The type of mixer should be used which will ensure thorough and accurate proportioning of the materials throughout the mass.

37. Where hand mixing is necessary the mixing should be done on a water-tight platform and special precautions taken to turn the materials until they are homogeneous in appearance and colour. Concrete that has started to set or has been out of the mixer more than thirty minutes should not be used. Re-tempering of either mortar or concrete which has partially hardened should not be permitted.

38. Concrete for reinforced concrete structures should not be mixed or deposited at a freezing temperature, unless special precautions are taken to avoid the use of materials containing frost and to provide means for preventing the concrete from freezing after being placed in position and until it has thoroughly hardened.

PLACING CONCRETE.

39. Concrete must be placed in the work immediately after mixing and deposited and rammed or agitated by suitable tools in such a manner as to produce thoroughly compact concrete or maximum density. No concrete should be placed until the reinforcing steel has been placed and firmly secured by wiring or other methods to prevent displacement. Concrete should be frequently wet for several days to prevent too rapid drying out.

40. Concrete should not be placed in water, unless unavoidable. Where concrete must be placed under water unusual care must be taken to prevent the cement from being floated away. This usually can be accomplished in still water by placing the

concrete through a large pipe or tube, or in large work by means of a bottom dump concrete basket. Before placing concrete, all shavings and debris of every nature must be removed and the concrete surface thoroughly cleaned and drenched with water.

FORMS.

41. Forms should be substantially built and secured to prevent movement or deflection during concreting, and tight to prevent leakage of mortar.

42. Before the removal of forms the concrete should be carefully inspected and its strength ascertained. Much care should be given to this portion of the work, which is fraught with danger under incompetent direction. No exact time for the removal of forms can be safely prescribed because of the varying character of the work, the variations in the setting of different cements and the influence of atmospheric conditions.

JOINTS.

43. Temperature changes and shrinkage during setting necessitate joints at frequent intervals or else effective reinforcement, depending upon the range in temperature and the design of the structure.

44. In massive work, such as retaining walls, abutments, etc., built without reinforcement, joints should be provided approximately every 30 to 50 ft. throughout the length of the structure.

45. Girders should never be constructed over freshly formed columns without allowing a period of at least two hours to elapse to permit settlement in the columns. Before resuming work the top of the column should be thoroughly cleansed of foreign matter and laitance.

46. To obtain tight joints between new and old concrete the old surface should be roughened, thoroughly cleaned of all foreign material and laitance or scum, drenched, and slushed with neat cement or a mortar not leaner than one part Portland cement to two parts fine aggregate.

47. Joints in reinforced concrete should be avoided when possible by casting the entire structure at one operation. In building construction, joints may be made in the columns flush with the lower side of the girders and joints in members of a floor system in general should be made at or near the centre of the span. In all cases joints should be at right angles to their surfaces.

DESIGN OF REINFORCED CONCRETE.

48. By the use of metal reinforcement to resist the principal tensile stresses, concrete becomes available for general use in a great variety of structures and structural forms. This combination of concrete and steel is particularly advantageous in the beam where both compression and tension exist; it is also advantageous in the column where the main stresses are compressive, but where cross bending may exist. The theory of design will therefore relate mainly to the analysis of beams and columns.

49. ***Loads.*** —The loads or forces to be resisted consist of :

(*a*) The *dead load,* which includes the weight of the structure and fixed loads and forces.

(*b*) The *live load* or the loads and forces which are variable. The dynamic effect of the live load will often require consideration. Any allowance for the dynamic effect is preferably taken into account by adding the desired amount to the live load or to the live load stresses. The working stresses hereinafter recommended are intended to apply to the equivalent static stresses so determined.

50. In the case of high buildings the live load on columns may be reduced in accordance with the usual practice.

51. ***Length of Beams and Columns.***—The span length for beams and slabs shall be taken as the distance from centre to centre of supports, but shall not be taken to exceed the clear span plus the depth of beam or slab. Brackets shall not be considered as reducing the clear span in the sense here intended.

52. The length of columns shall be taken as the maximum unsupported length.

WORKING STRESSES.

53. The working stresses given below are as recommended by the Joint Committee on Concrete and Reinforced Concrete for limiting values.

54. ***General Assumptions.***—The following working stresses are recommended for static loads. Proper allowances for vibration and impact are to be added to live loads

where necessary to produce an equivalent static load before applying the unit stresses in proportioning parts.

55. In selecting the permissible working stress to be allowed on concrete, we should be guided by the working stresses usually allowed for other materials of construction, so that all structures of the same class but composed of different materials may have approximately the same degree of safety.

56. The stresses for concrete are proposed for concrete composed of one part Portland cement and six parts aggregate, capable of developing an average compressive strength of 2,000 pounds per square inch at twenty-eight days, when tested in cylinders 8 in. in diameter and 16 in. long, under laboratory conditions of manufacture and storage, using the same consistency as is used in the field. In considering the factors recommended with relation to this strength, it is to be borne in mind that the strength at twenty-eight days is by no means the ultimate which will be developed at a longer period, and therefore they do not correspond with the real factor of safety. On concretes, in which the material of the aggregate is inferior, all stresses should be proportionately reduced, and similar reduction should be made when leaner mixes are to be employed. On the other hand, if, with the best quality of aggregates, the richness is increased, an increase may be made in all working stresses proportional to the increase in compressive strength at twenty-eight days, but this increase shall not exceed 25 per cent.

57. **Bearing.*** —For compression on surface of concrete larger than loaded area,

32·5 per cent. of compressive strength at twenty-eight days, or 650 pounds per square inch on 2,000 pound concrete.

58. **Plain Columns.**—Plain columns or piers whose length does not exceed twelve diameters,

22½ per cent. of compressive strength at twenty-eight days, or 450 pounds per square inch on 2,000 pound concrete.

59. **Reinforced Columns.** — (See paragraphs 96 to 104 on Columns.)

60. **Compression in Extreme Fibre.**—For extreme fibre stress of beams calculated for constant modulus of elasticity,

32·5 per cent. of the compressive strength at twenty-eight days, or 650 pounds per square inch for 2,000 pound concrete.

61. Adjacent to the support of continuous beams, stresses 15 per cent. greater may be allowed.

62. **Shear.** —Pure shearing stresses uncombined with compression or tension,

6 per cent. of compressive strength at twenty-eight days, or 120 pounds per square inch for 2,000 pound concrete.

63. **Diagonal Tension.**—In beams where diagonal tension is taken by concrete the vertical shearing stresses should not exceed 2 per cent. of compressive strength at twenty-eight days, or 40 pounds per square inch for 2,000 pound concrete.

(See also paragraph 88, Shear and Diagonal Tension.)

64. **Bond for Plain Bars.**—Bonding stress between concrete and plain reinforcing bars,

4 per cent. of compressive strength at twenty-eight days, or 80 pounds per square inch for 2,000 pound concrete.

For drawn wire.

2 per cent., or 40 pounds on 2,000 pound concrete.

65. **Bond for Deformed Bars** —Bonding stress between concrete and deformed bars may be assumed to vary with the character of the bar from

5 per cent. to 7½ per cent. of the compressive strength of the concrete at 28 days or from

100 to 150 pounds per square inch for 2,000 pound concrete.

66. **Reinforcement.** —The tensile stress in steel should not exceed 16,000 pounds per square inch. The compressive stress in reinforcing steel should not exceed 16,000 pounds per square inch, or fifteen times the working compressive stress in the concrete.

67. **Modulus of Elasticity.** —It is recommended that in all computations the modulus be assumed as $\frac{1}{15}$ that of steel; that is, that a ratio of fifteen be employed.

(*To be continued.*)

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* For beams and girders built into pockets in concrete walls, the lower Compressive Stress of 450 bs. per sq. in. should not be exceeded.

REINFORCED CONCRETE SEWER CONSTRUCTION IN SAN FRANCISCO.

By **ERNEST R. MATTHEWS, A.M.Inst.C.E., F.R.San.I.**
Borough Engineer of Bridlington.

This article on the Reinforced Concrete Sewers in San Francisco should be read in conjunction with Mr. Matthews' previous articles on this subject generally, several of which have been published from time to time in our earlier issues.—ED.

REINFORCED concrete has very much to recommend it as a material for use in the construction of sewers, aqueducts, and conduits; some of the advantages claimed for this method of construction being:

(1) Economy in cost.
(2) Rapidity in construction.
(3) Low cost of maintenance.
(4) Its hygienic value.
(5) Increases in strength with age.

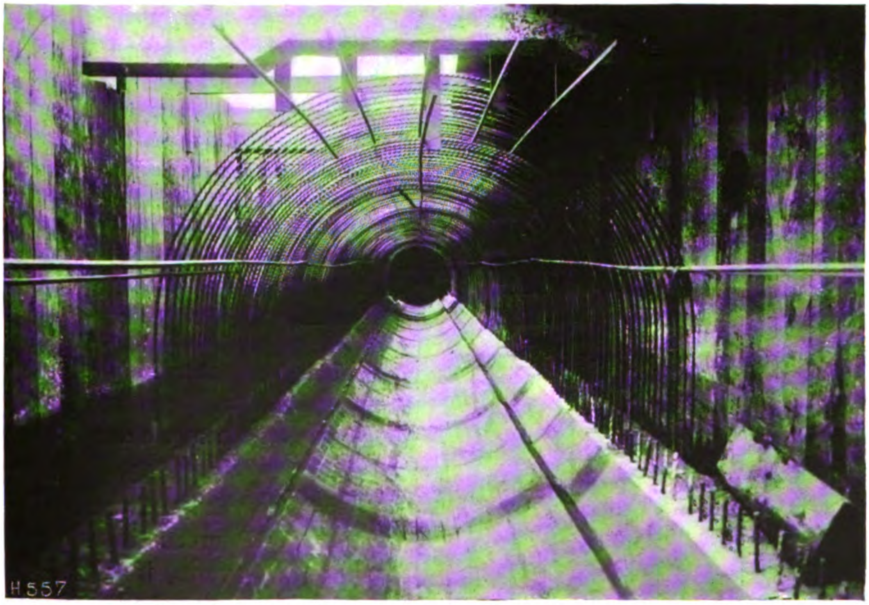


FIG. 1. 6-FT. OUTFALL SEWER IN REINFORCED CONCRETZ IN MARIPOSA STREET, SAN FRANCISCO.

In preparing his scheme for the improvement of the sewerage system of San Francisco, the City Engineer, Mr. Marsden Manson, C.E., Ph.D., has carefully considered these advantages, and he says, in writing to the author: "We find this class of work (reinforced concrete work) suitable to our conditions, and considerably cheaper than brickwork. The fact that we are using this material in preference to any other is abundant proof of our opinion as to its suitability."

The author will now describe in detail some of the new sewers which have recently been constructed in this important American city, and he would here remark that the reinforcement which has been inserted in these sewers is theoretically heavier than would be required under ordinary conditions, owing to the liability of the city to frequent light earthquake shocks, and, at intervals of about half a century, rather heavy ones.

Mr. Manson informs the author that reinforced concrete structures, if properly constructed, entirely

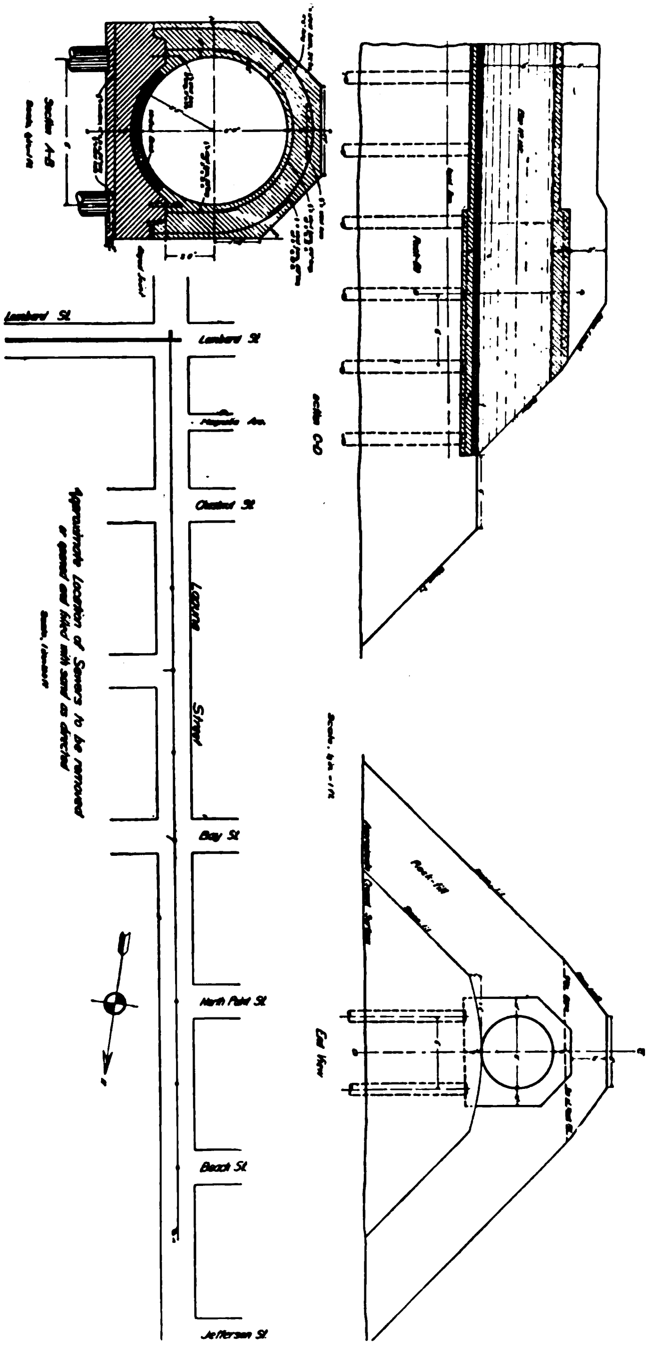
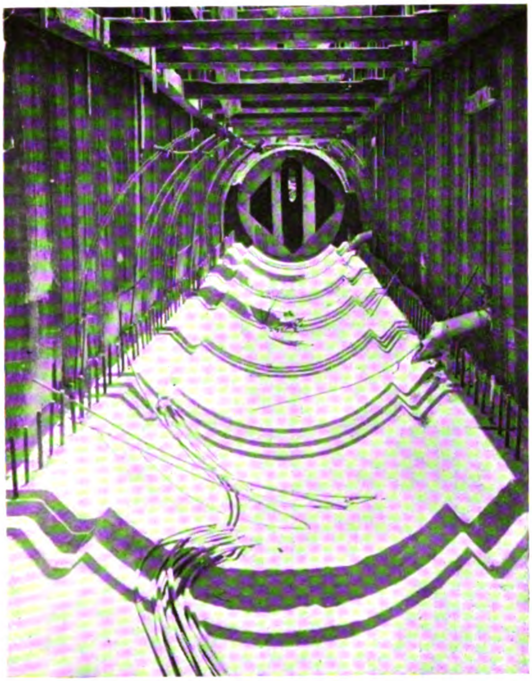


Fig. 2. Plan for Construction of Laguna Street Outfall Sewer.

Showing concrete and vitrified brick invert.



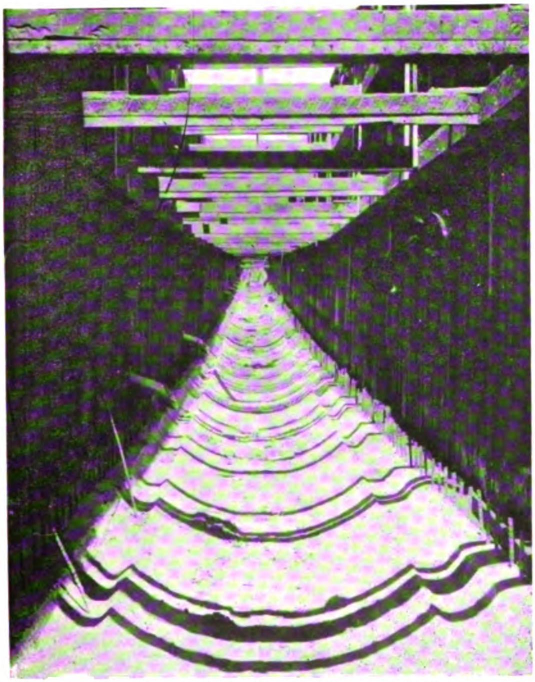


Fig. 3 The Laguna Street Outfall Sewer.

escape damage as a result of the shocks referred to.

THE LAGUNA STREET OUTFALL SEWER.

This sewer is illustrated in *Fig.* 3. The photographs show the work in progress, and the reinforcement and invert work. The protection of the outer end of the sewer is also shown.

The sewer is 6 ft. internal diameter, and is carried on piles which are spaced at 6-ft. centres. It is constructed throughout of reinforced concrete, the invert being formed in vitrified bricks. The reinforcement consists of $\frac{5}{8}$-in. and $\frac{1}{2}$-in. square steel bars of various lengths, spaced at 9-in. centres (see *Fig.* 2). The walls and top and bottom slabs are 18 in. in thickness, and the concrete is composed of Portland cement, sand, and broken rock in the proportion of 1 cu. ft. of cement to 5 cu. ft. of rock, with enough sand to fill the voids in the rock. The concrete was deposited in layers not over 5 in. thick, between strong forms of the correct shape and dimensions, and rammed well into position to insure a homogeneous structure and a perfect union with the lower course.

It will be noticed that a key was made in the concrete on top of the bottom slab.

When a fresh layer of concrete was put on one which had set, the entire surface was previously cleaned, made thoroughly wet, and covered with a layer of cement mortar composed of Portland cement and sand, 1 to 2.

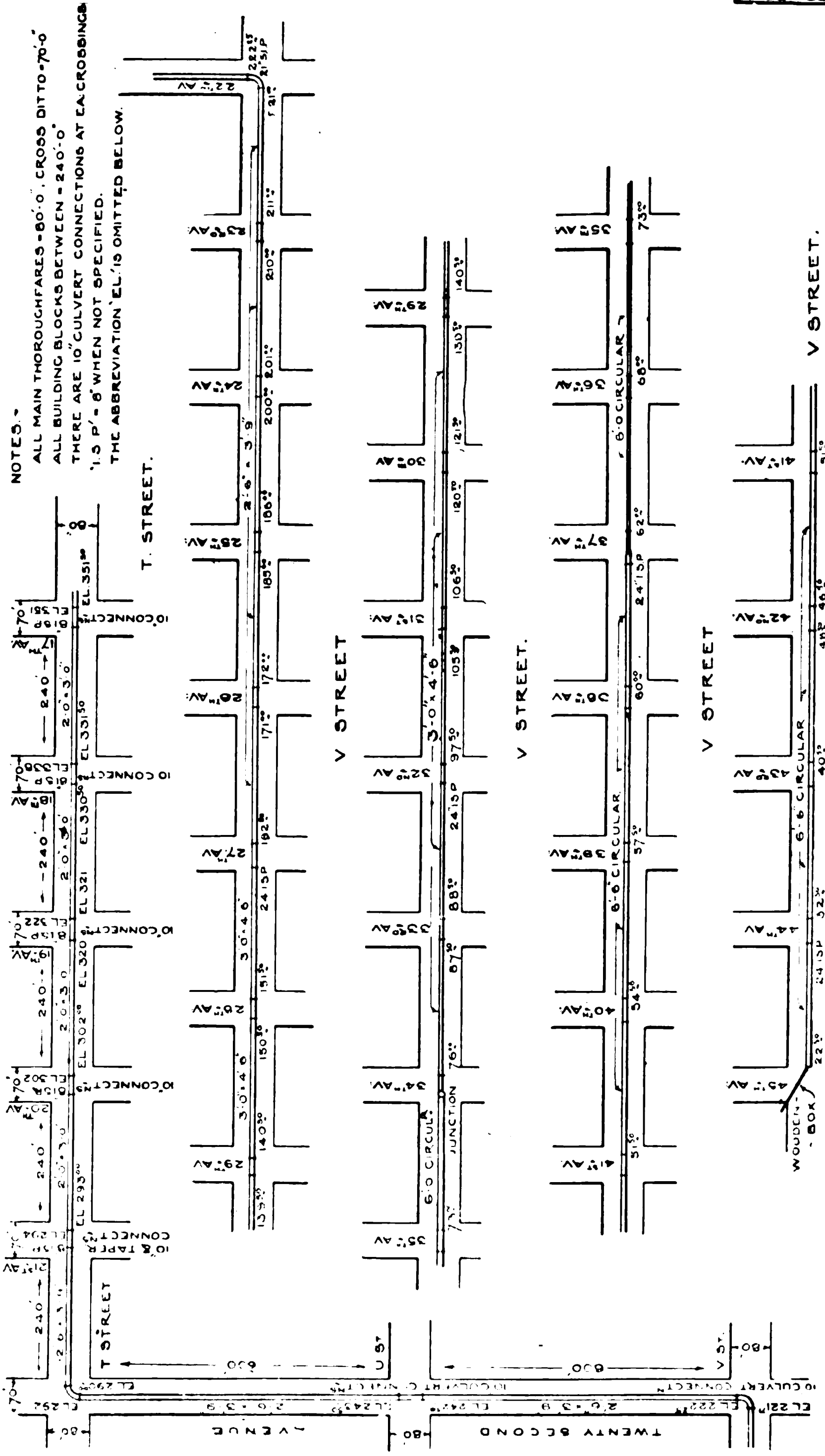

NOTES.-
ALL MAIN THOROUGHFARES - 80'-0. CROSS DITTO - 70'-0"
ALL BUILDING BLOCKS BETWEEN - 240'-0"
THERE ARE 10" CULVERT CONNECTIONS AT EA. CROSSINGS
1.5 P' = 8" WHEN NOT SPECIFIED.
THE ABBREVIATION 'EL.' IS OMITTED BELOW.
T. STREET.
V STREET
V STREET.
V STREET
V STREET.
T STREET
TWENTY SECOND AVENUE
WOODEN BOX

FIG. 4. PLAN OF SEWERS AND APPURTENANCES IN "T" AND "V" STREETS, SAN FRANCISCO.

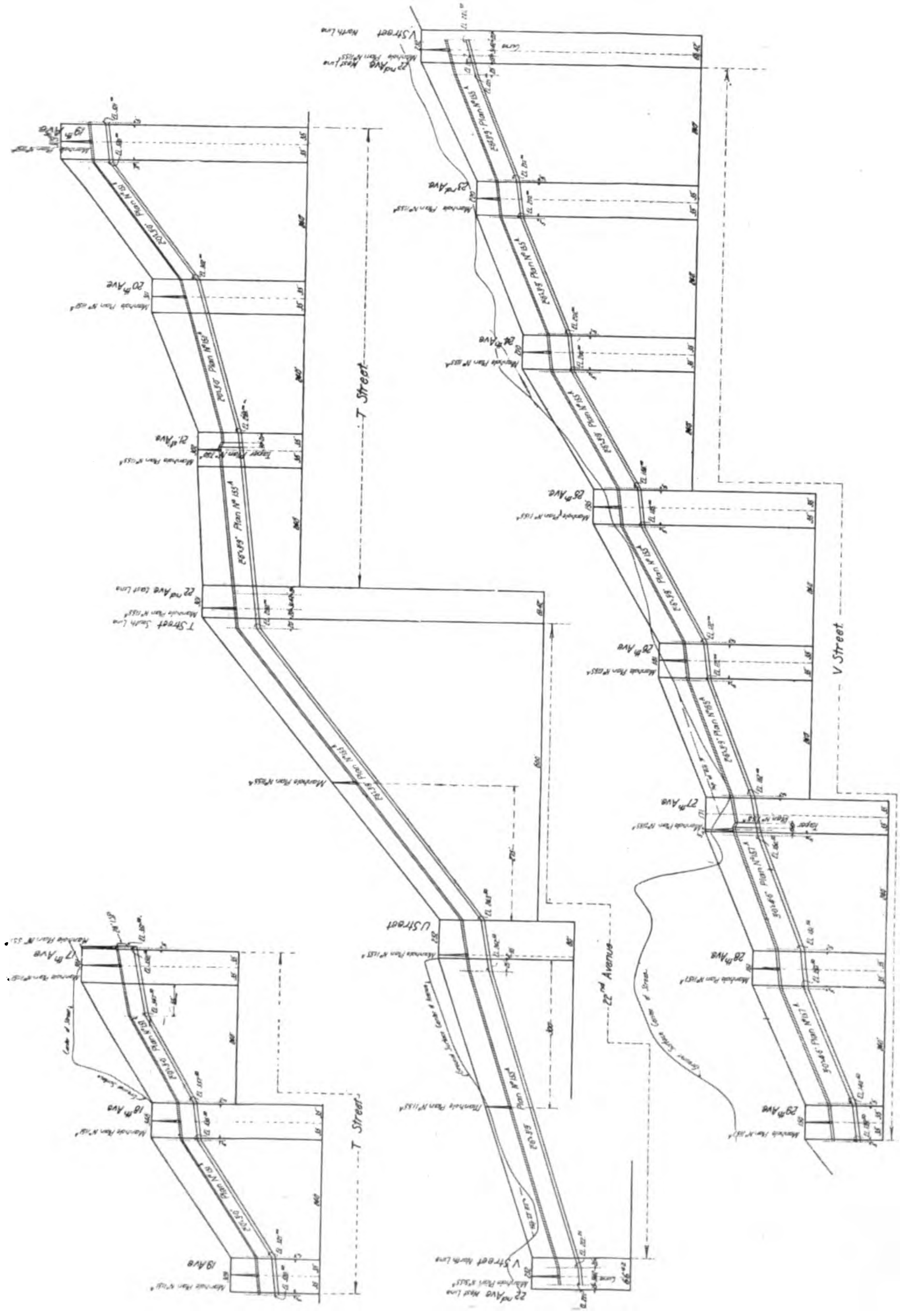


FIG. 5. SECTION OF SEWERS IN "T" AND "V" STREETS, SAN FRANCISCO.

All exposed concrete was carefully protected from the weather, and was occasionally wetted down.

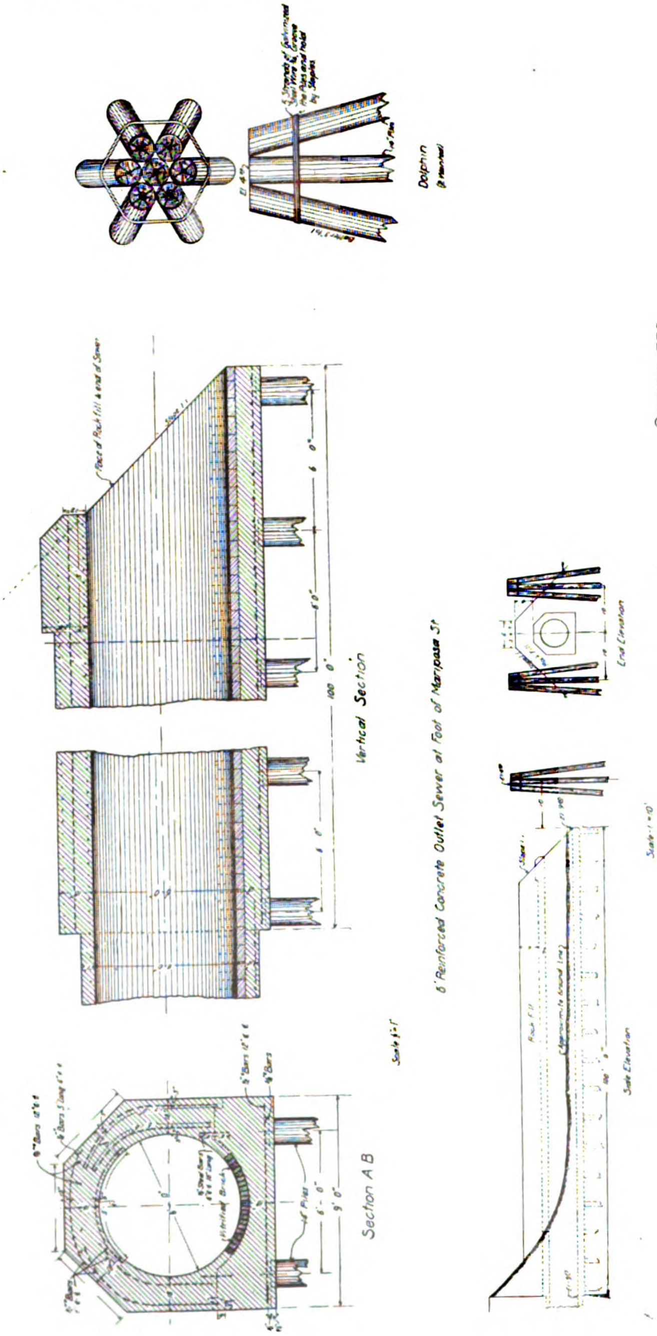


FIG. 6. DETAIL OF EAST POTRERO INTERCEPTING SEWER, SHOWING OUTLET, ETC.

Provision for expansion and contraction in the concrete was made by finishing off each day's work in steps, and using tarred paper in the joint formed when the new work was added.

The cement used was the first quality Portland cement complying with the following conditions:

Briquettes made with a Bohme hammer, from neat cement, after being kept one day in moist air, and the remainder of time in water, to develop a tensile strength per sq. in. as follows: At 7 days, 500 lb.; at 28 days, 600 lb.; 3 to 1 briquettes to develop a strength of 200 lb. after 7 days, and 300 lb. after 28 days. The sand used in this test to be clean, sharp quartz, capable of passing a 20-mesh, and of being rejected by a 30-mesh sieve.

Pats of neat cement about 3 in. in diameter and ½ in. in thickness at centre, tapering to a thin edge, being kept in moist air at normal temperature for

24 hours, and then placed in water and raised to a temperature of 212° Fahr. in one hour, and maintained at such temperature for 5 hours, and other pats kept, one in open air and one in water, at a temperature of about 65°Fahr. for 28 days, to show no signs of distortion, cracking, or disintegration.

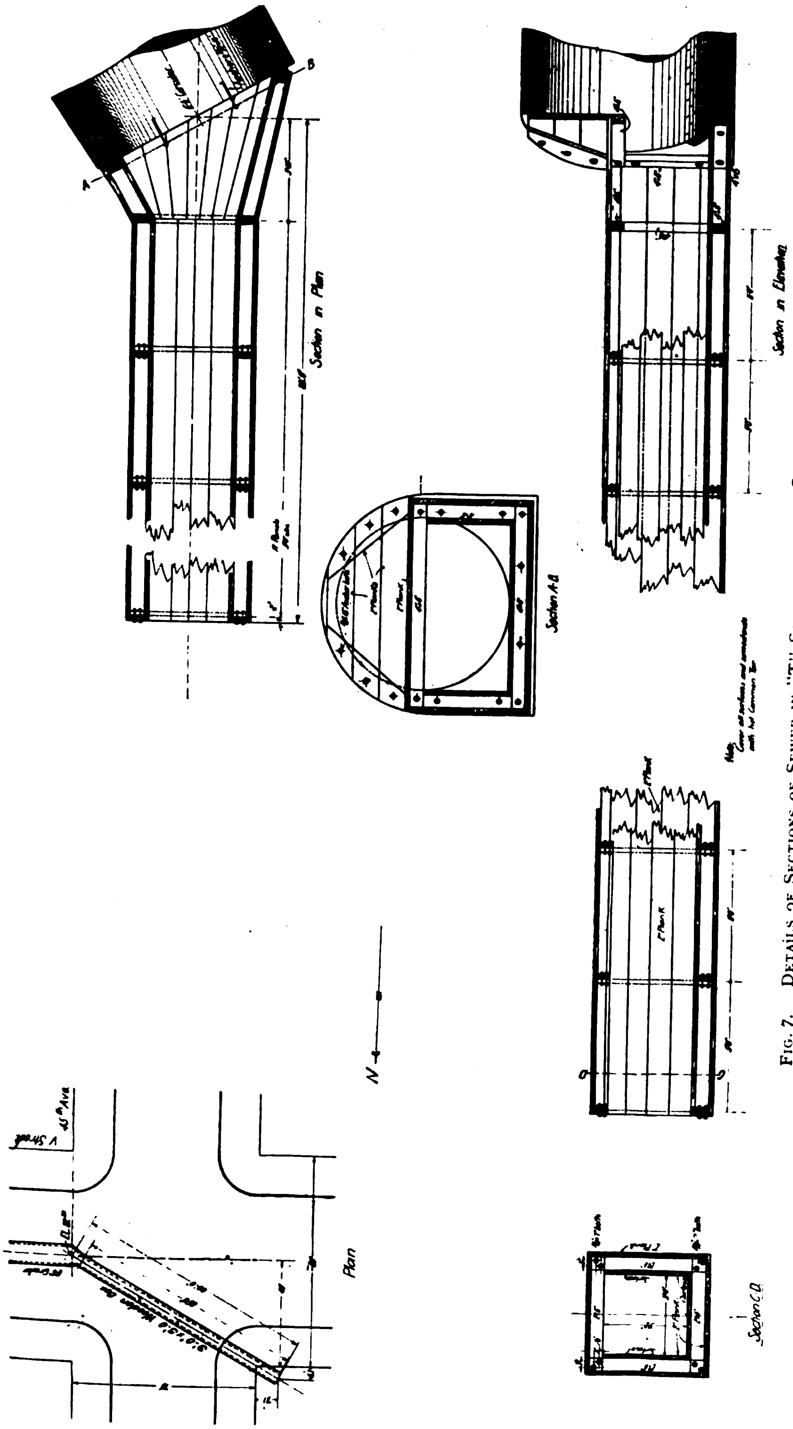


Fig. 7. Details of Sections of Sewer in "T" Street, showing Centering

At least 92 per cent. of the cement, by weight, to pass through a sieve of 10,000 meshes to the sq. in., and at least 77 per cent. through a sieve of 40,000 meshes to the sq. in.

The sand had to be capable of passing the following mesh tests:

At least 60 per cent. by weight to pass a 20-mesh screen, not more than 85 per cent. to pass a 50-mesh screen, and not more than 15 per cent. to pass an 80-mesh screen.

The sandstone rock was specified to be close grained and sound.

Two - thirds to be broken to

pass through a 2-in. screen, and to be rejected by a 1¼-in. screen; the other one-third to pass a 1¼-in. screen, and be rejected by a ⅜-in. screen.

Steel Bars.—Steel bars for reinforcing concrete were specified to have irregular surfaces of such shape as would assist their adhesion to the concrete, and the area of their minimum section had to be equivalent to the area indicated on the plans. The steel to have a tensile strength of not less than 60,000 lb. per sq. in., and an elastic limit of not less than 30,000 lb. per sq. in., and to be capable of being bent cold through an angle of 180° around a circle whose diameter is equal to twice that of the bar, without fracture of the outside fibres.

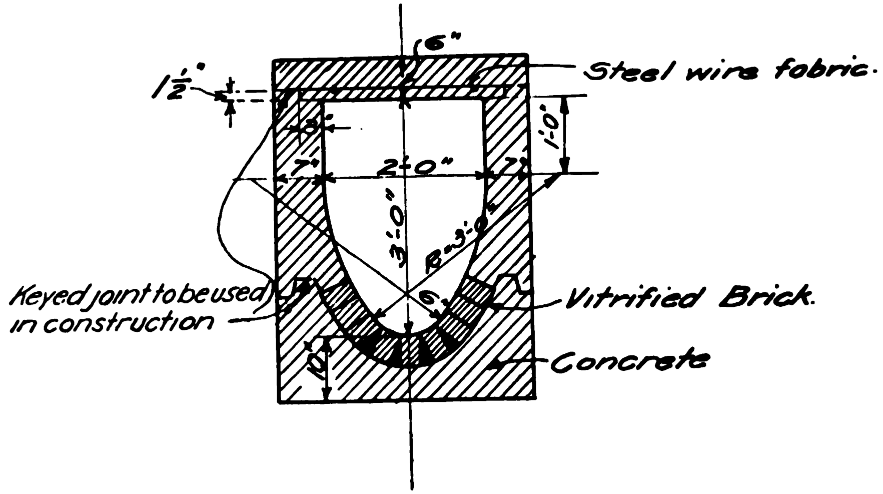


FIG 8. 2 FT. BY 3 FT. EGG-SHAPED SEWER WITH FLAT TOP IN "T" STREET.

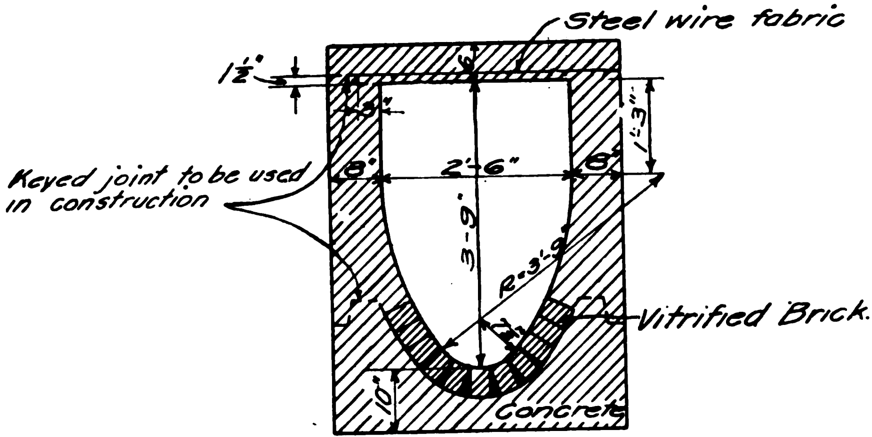


FIG. 9. 2 FT. 6 IN. BY 3 FT. 9 IN. EGG-SHAPED SEWER WITH FLAT TOP IN "T" AND "V" STREETS.

Forms.—The forms and centres were of dressed pine, laid with close joints, and where necessary in order to prevent the concrete adhering to the form, the surfaces were coated with crude petroleum or tallow.

Vitrified Bricks.—The invert was formed with these, the size of the bricks being 2½ in. by 4 in. by 8¾ in. After immersion in water for 72 hours (the bricks being broken transversely), the total absorption was not to exceed 2 per cent. of the weight of the bricks when dried.

Mixing of the Concrete.—This was done with a Ransome machine.

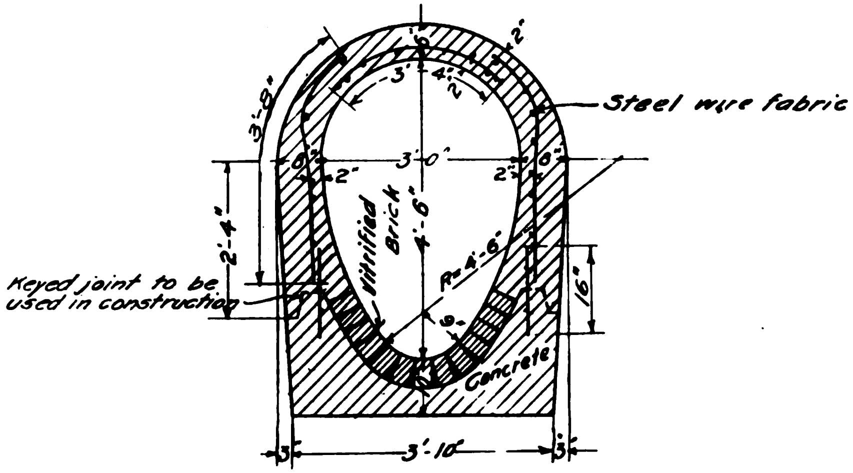


FIG. 10. 3 FT. BY 4 FT. 6 IN. REINFORCED CONCRETE SEWER, WITH SEMICIRCULAR TOP, IN "T" AND "V" STREETS.

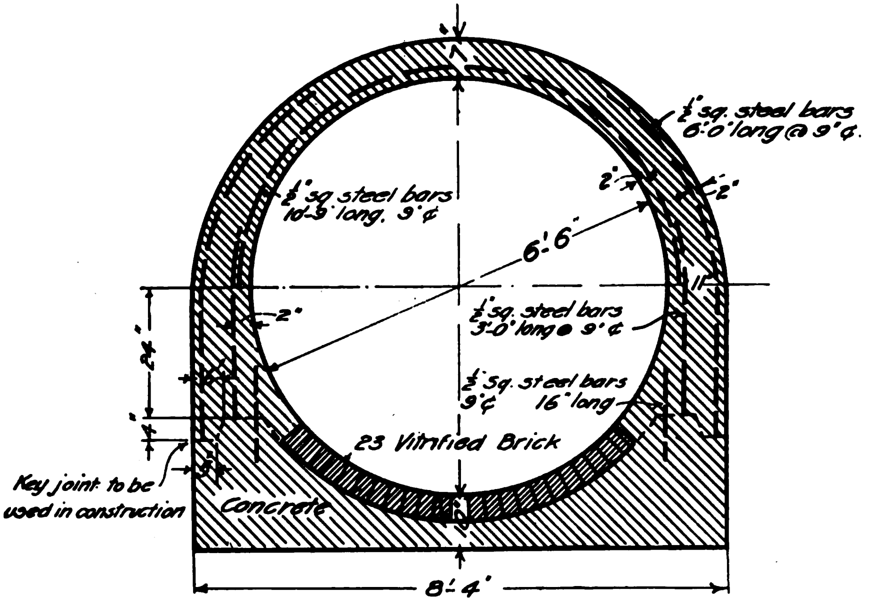

½" sq. steel bars 6'0" long @ 9" ¢.
2"
2"
½" sq. steel bars 10'-9" long. 9" ¢
6'-6"
11"
2"
½" sq. steel bars 3'-0" long @ 9" ¢
24"
½" sq. steel bars 9" ¢ 16" long
23 Vitrified Brick
Key joint to be used in construction
Concrete
8'-4"

FIG. 11. 6 FT. 6 IN. CIRCULAR REINFORCED CONCRETE SEWER.

REINFORCED CONCRETE OUTLET SEWER AT FOOT OF MARIPOSA STREET.

This is a similar sewer, and is also 6 ft. in diameter. It is illustrated in *Fig.* 1. The sewer is carried on 14-in. piles spaced at 6-ft centres.

EGG-SHAPED AND OTHER SEWERS.

Standard Egg-shaped Sewers with Flat Tops.—Most of the smaller egg-shaped sewers have reinforced concrete tops. The 2 ft. by 3 ft. and 2 ft. 6 in. by 3 ft. 9 in. sewers, in "T" and "V" Streets, for example (see *Figs.* 8 and 9), are constructed of plain concrete, and are covered with a reinforced concrete slab 6 in. in thickness; the reinforcement consisting of steel wire fabric, and two longitudinal steel rods. The reinforcement is placed on the underside of the slab, and has a covering of 1½ in. of concrete. The concrete is in the same proportion as in the outfall sewers previously described, and a fairly wet mixture was put in.

Vitrified bricks form the invert. A key was formed in the concrete where the walls join the foundation slab. The thickness of the walls in the 2 ft. by 3 ft. sewers is 7 in., and in the 2 ft. 6 in. by 3 ft. 9 in. is 8 in.

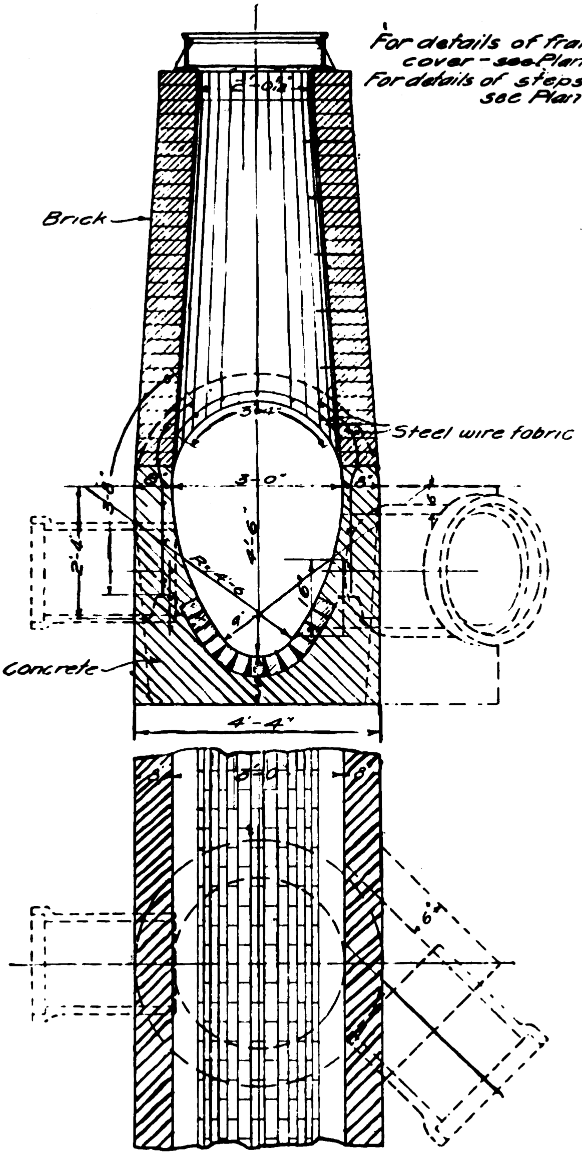

For details of frame & cover - see Plan #350
For details of steps see Plan #399
Brick
Steel wire fabric
Concrete
2'-0½"
3'-4"
3'-0"
4'-6"
R 4'-6"
2'-4"
8"
6"
4'-4"
3'-0"

Fig. 12. Circular Manhole on 3 ft. by 4 ft. 6 in. Reinforced Concrete Sewer.

Standard Egg-shaped Sewers with Semicircular Tops.—These are illustrated in *Fig.* 10, which represents a sewer 3 ft. by 4 ft. 6 in. in size, constructed of reinforced concrete. The walls are 8 in. in thickness, the top 6 in. The reinforcement consists of steel wire fabric and longitudinal steel bars, and the invert is formed of vitrified bricks. The walls are keyed into the foundation slab.

Standard Reinforced Concrete Circular Sewers. — *Fig.* 11 represents a 6 ft. 6 in. circular sewer of reinforced concrete, with the inverts lined with vitrified bricks. The reinforcement consists of ½-in. sq. steel bars of various lengths, spaced at 9 in. centres. The thickness of the arches at crown is 7 in., and there is a 2-in. covering to all reinforcement. The walls are keyed into the foundation slabs.

Manholes for Reinforced Concrete Sewers.—These are shown in *Figs.* 12 and 13. They are oval and circular in shape respectively, and are built in the manner illustrated.

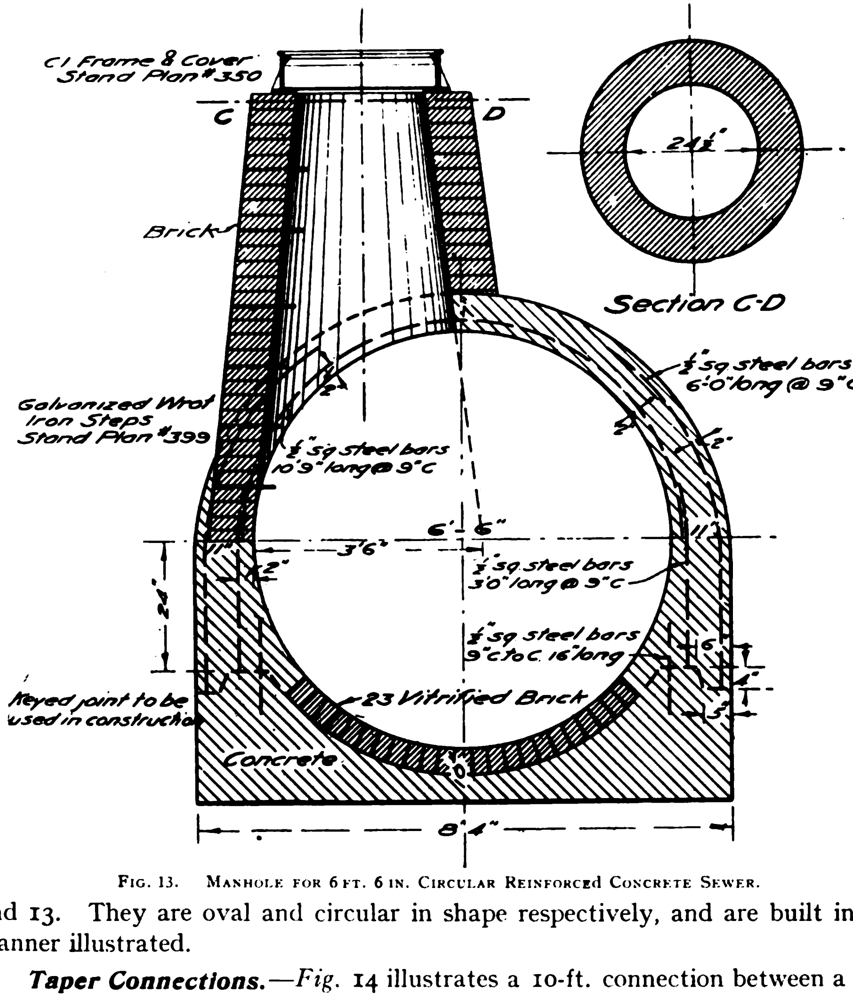


FIG. 13. MANHOLE FOR 6 FT. 6 IN. CIRCULAR REINFORCED CONCRETE SEWER.

Taper Connections.—*Fig.* 14 illustrates a 10-ft. connection between a 6 ft. and a 6 ft. 6 in. reinforced concrete circular sewer, and clearly indicates how useful this material is when connections similar to these have to be made.

Conclusion.—It will be clearly seen by reference to the various illustrations accompanying this article, that reinforced concrete can be used, and has been used in San Francisco, to great advantage in sewer construction, and the author hopes that English engineers will give this material a trial in work of this class, for he is confident that reinforced concrete is eminently suitable for this purpose.

The author would express his indebtedness to the City Engineer of San Francisco, Mr. Marsden Manson, C.E., Ph.D., for supplying him with the information contained in this article, and for allowing him to publish the illustrations.

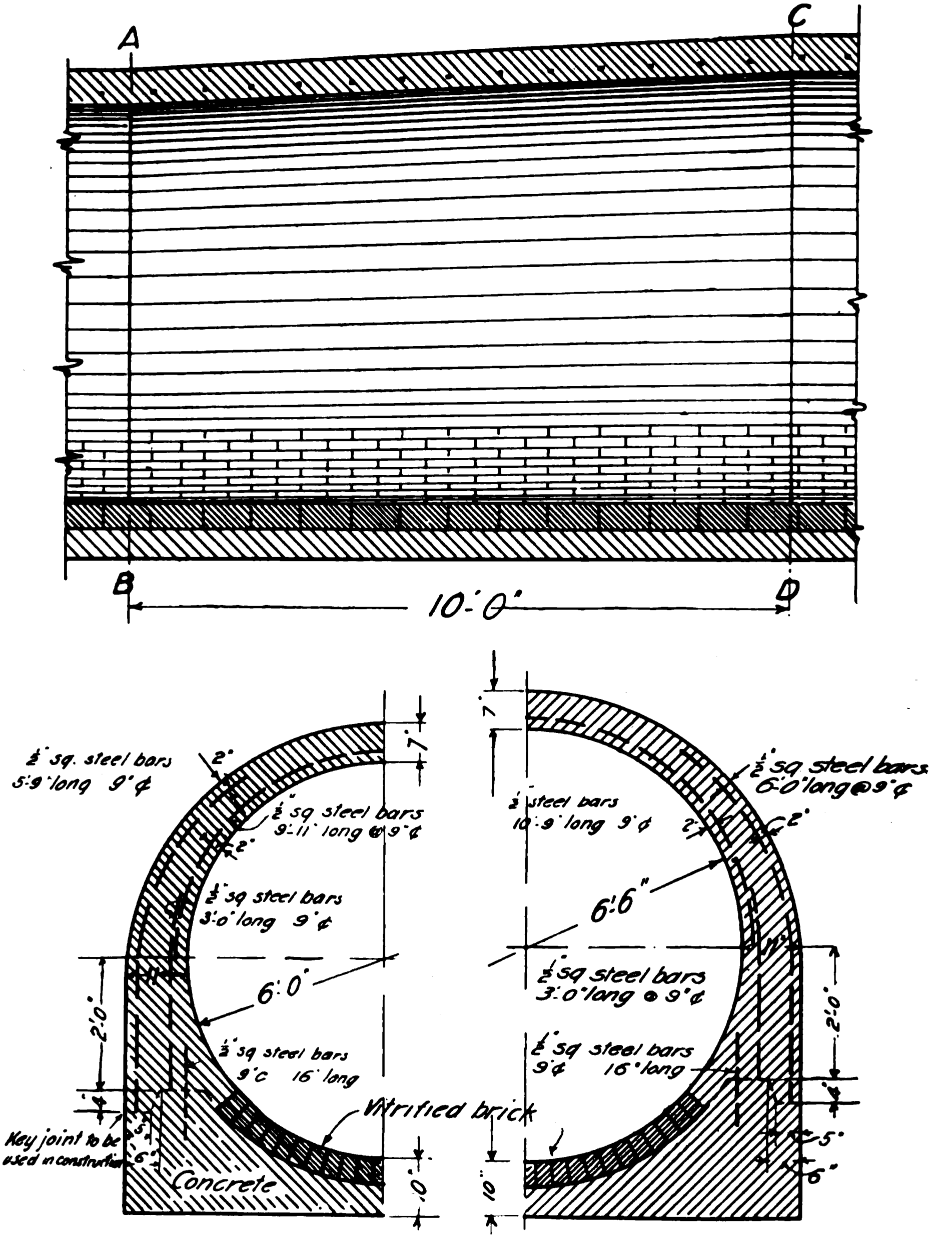
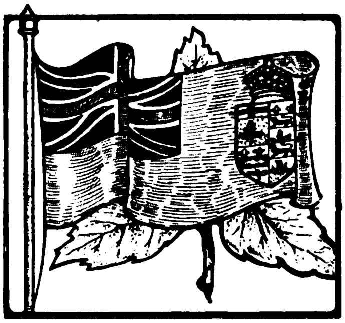

A
C
B
D
10'-0"
½" sq. steel bars 5'-9" long 9" ¢
2"
½" sq steel bars 9'-11" long @ 9" ¢
2"
7"
½" sq steel bars 3'-0" long 9" ¢
6'-0"
2'-0"
4"
½" sq steel bars 9" c 16' long
Vitrified brick
Key joint to be used in construction
5"
6"
Concrete
10"
7"
½" steel bars 10'-9" long 9" ¢
½" sq steel bars 6'-0" long @ 9" ¢
2"
2"
6'-6"
½" sq steel bars 3'-0" long @ 9" ¢
½" sq steel bars 9" ¢ 16' long
2'-0"
4"
5"
6"
10"

FIG. 14. 10 FT. TAPER CONNECTION OF REINFORCED CONCRETE FROM 6 FT. CIRCULAR SEWER TO 6 FT. 6 IN. CIRCULAR SEWER.



CONCRETE AS DISCUSSED AT THE CANADIAN CEMENT AND CONCRETE ASSOCIATION.

The Second Annual Convention of the Canadian Cement and Concrete Association was held at London, Ontario, in March last, and we are publishing some of the most interesting of the papers read on that occasion.—ED.

THE USE OF CONCRETE IN THE CONSTRUCTION OF PAVEMENTS.

By JAMES PIERSON, Toronto, Ontario.

THERE is no branch of applied science that has in recent years made more progress or arrived at a state nearer to perfection than that of civic road making, or the construction of pavements.

To-day we have the outcome of this progress evidenced in the up-to-date asphalt and other smooth surfaced pavements laid on an unyielding, rigid and durable foundation—pavements easily repaired and capable of being kept absolutely clean and sanitary by flushing or washing, and furnishing to the citizens the greatest possible facilities, convenience and comfort in travel, and at the same time adding greatly to the beauty and general appearance of our streets.

As an evidence of the progress that is being made in this respect, I may mention that in Toronto alone, in 1908, there were laid twenty-five miles of pavements on a concrete base of foundation, consisting of twenty-one miles of asphalt and four miles of other kinds, such as brick and asphalt block, and all with a concrete curb and gutter, except the brick, which has a curb but no gutter. In the same year there were laid fifty-five miles of concrete sidewalks, making a total of 340 miles of such walks in that city up to the end of 1908, and 1909 had about as much concrete paving work done as 1908. Toronto has now about 120 miles of asphalt pavements all laid on concrete, varying from 4 in. to 6 in. in depth. Other towns and cities are making corresponding progress, and using enormous quantities of cement in the work.

It will be my object in this brief paper to endeavour to show how these greatly changed conditions were effected and the important part played by Portland cement on concrete in the bringing of them about.

Macadam Roads.—Going back, we find the first important step towards improvement in road making was the invention of John L. Macadam, who, in or about the year 1818, devised the road made of broken stone which is still known by his name, and, so far as country roads are concerned, it is still the recognised standard all over the civilised world, and when well laid is a good one for country use, but when heavily travelled it requires constant repair, and since the advent of the motor-car it will be still more difficult to keep in good condition.

Although no change has been made up to the present time in the construction of the macadam road, this device did have something to do in the development or evolving of the ideal smooth-surfaced pavement, with concrete foundation, of the present day. In the district of Val de Travers, Canton of Neuchâtel, Switzerland, macadam roads were made of a broken brown bituminous limestone. Under the pulverising effect of the traffic and the influence of the sun in softening the bitumen the surface of the pavement became welded together in a continuous sheet, and in 1854 the first pavement of this material was laid in Paris on Rue Bergère, and this is what is known as rock asphalt, now so extensively used throughout the cities of Europe. It has also been used to some extent in a few of our own Canadian seaport towns and Ottawa.

Asphalt Paving.—The success of this bituminous rock as a pavement led a French chemist named Edward De Smedt to analyse it. He came to America in 1870, and among his experiments to devise a practical paving material similar in effect to the Neuchâtel bituminous rock, but less expensive, he tried the use of a mixture of Trinidad asphalt with sand, and laid samples of pavement with it in several American cities to keep alive his patents.

Necessity of Concrete Base.—In experimenting it was found that asphalt, whether Val de Travers, Trinidad, or any other, was only serviceable as a surfacing material, and to make a pavement with it, a firm and rigid base of foundation was absolutely necessary. As a surfacing material, smooth, easily kept clean, and repaired, sand and pulverised limestone mixed with sufficient asphalt to cement them together made the nearest approach to the ideal pavement surface that had yet been hit upon, but it was absolutely useless without a rigid base to support it, so a cement concrete was tried and found to meet the requirements, thus the use of concrete originated as an asphalt pavement base.

Noting the utility and success that attended concrete as a base or foundation for asphalt pavements, it has been adopted generally by civic engineers as a base for most other pavements, such as brick, vitrified block, asphalt block, and even granite block is now laid on concrete, as experience proves that it gives and maintains a more even surface to any class of pavement.

As a base it has many advantages over any other foundation. On streets where the subsoil has been cut and disturbed by putting down sewers, water and gas pipes, and making connections with buildings, and where a settling is likely to take place, a good 5 or 6 in. concrete will maintain any ordinary traffic, even if unsupported at these cuts.

Concrete Curbs.—Its use has also entirely supplanted the use of stone in curbs and gutters, and with great economy as to cost; a stone curb and gutter that would cost about $1.00 (4s.) per lineal foot can be laid for half that cost with cement, while the latter far excels the former in durability and appearance. Stone curbs made of straight blocks do not compare in appearance with the graceful curve of a concrete construction on a winding street, nor will stone curbs remain in position, no matter how well set, owing to the depth of the frost in our cold winters. The recognised construction of concrete curb and gutters now is to have them constructed on the concrete base and at the same time. This saves material and forms one solid body, consisting of base, curb, and gutter. Sometimes when the sidewalk is constructed before the pavement, and is placed out adjoining where the pavement is to be, the curb is built as a part of the walk, and is then made of sufficient depth to form a curb to the bottom of the base of the intended pavement.

Concrete for Car Tracks.—As a base for pavements concrete has another advantage in that it can be laid on ground that is wet and even soft, as moisture only improves its quality, and being a solid body it will bear up the traffic, even if there are weak spots underneath. Its use is now revolutionising the construction of those parts of street pavements occupied by street car lines or tracks. Heretofore the rails have been almost entirely laid on wooden sleepers resting on the ground. With the modern large street car and heavy traffic tracks so laid are continually sinking, so that the rails have at great expense and inconvenience to traffic to be frequently shimmed up to keep the motors underneath clear of the pavement. By the use of concrete, however, under the sleepers, or under the rails without sleepers, a rigid and permanent track can be had, and the pavement between the rails kept even with that on the outside, thus giving the whole street an even and durable surface, except as to the groove for the flange of the car wheels to run in.

Durability of Concrete.—These are some of the advantages recognised in the use of concrete as a base for the modern pavements, but the greatest of all is its durability.

It is permanent, so that when the wearing surface wears out, which in time all wearing surfaces will, it is still there as good as ever ready for a new top, and thus it is in the end the most economical. In fact, so generally recognised has concrete become as the proper base for all the best pavements that the proper definition for a permanent pavement as distinguished from others may be said to be a pavement having a concrete base.

I would here tender some advice to the small towns that are raising funds for permanent pavements on their main streets, that no matter what surface they adopt, whether asphalt, asphalt block, brick, or bituminous macadam, they should insist on a concrete base. In this they will then always have a valuable asset—a base that can be re-surfaced from time to time after the first one wears out. It will prove to be the most economical in time.

Wearing Surface.—With regard to the use of concrete as a wearing surface, while it is recognised as the most excellent material, when properly made, for sidewalks, presenting a beautiful surface that wears evenly and is more durable than stone, except perhaps granite, yet it does not form a good wearing surface for a busy street with much vehicular traffic with iron tyres. But it is now being adopted rather extensively for paving lanes and areas where there is little traffic.

If the time should come when increased travel by the rubber tyre motor car should demand roads set apart for their exclusive use, a concrete pavement would, I believe, make the most ideal one.

In conclusion, I may add that the recently reduced cost of Portland cement in comparison with former years will add an additional incentive to the use of this most valuable material in the construction of modern pavements and the beautifying of our towns and cities.

WATERPROOFING CONCRETE.

By R. A. PLUMB, Detroit, Mich., U.S.A.

BUILDING materials in general, especially concrete, are decidedly porous and absorbent. Water is drawn into foundations from the surrounding soil, and due to the capillary nature of constructive materials, it ascends gradually and finally permeates the entire structure, producing damp, clammy walls which constantly foster and spread disease. It is apparent, therefore, that proper waterproofing not only prevents the gradual decay and disintegration of structural materials, but goes to establish more hygienic conditions for the benefit of humanity in general. We are all willing to grant that if we can add permeability to the strength, durability and fire-resisting properties of concrete, we have at last produced a perfect building material.

In recognition of the distinct differences between damp-proofing and waterproofing in its literal interpretation, it is advisable to consider these subjects as two separate divisions of the general subject of protecting structures against the disintegrating action of water. Damp-proofing should be confined to the consideration of the methods and processes of keeping water and dampness out of the superstructures of buildings, while waterproofing should deal particularly with methods of treating and insulating substructural work subject to hydrostatic pressure, and also to those types of construction designed for retaining water. Damp-proofing products have absolutely no application to waterproofing conditions, and manufacturers of strictly damp-proofing products, who are pushing their materials for waterproofing conditions, are only bringing discredit on the whole subject of waterproofing.

DAMP-PROOFING.

The almost innumerable number of materials on the market for damp-proofing purposes may be simply included in three distinct classes, *viz.:*

(1) Transparent Coatings.
(2) Opaque Cement Coatings.
(3) Special Bituminous Coatings.

Transparent Coatings.—In this class should correctly be included the products and processes, the application of which does not change the original physical appearance of the surface treated.

The old Sylvester process, although now practically obsolete, should be given some mention as an original effort in this line of damp-proofing. This process involves alternate treatments of the surface with solutions of soap and alum, and depends for its efficiency upon the formation of a greater or lesser amount of the aluminium salts of the fatty acid contained in the soap, which possesses, physically, a very distinct but temporary water-repellent action. This is not economical, as it is necessary to repeat the operations a number of times to produce sufficient insoluble soap to show any efficient repellent action.

The treatment of the porous surface by means of hot paraffin should also be included in this class. In this process the exposed surfaces are first very carefully heated by means of artificial heat and coated with melted paraffin applied with a brush. By this means the paraffin penetrates to a considerable depth before it chills and leaves the paraffin deposited in the pores. Comparatively successful results can be obtained by this method, yet the expense makes its use quite prohibitive in the majority of cases.

Most interesting of this class are the great number of transparent liquid coatings that are applied to the surface with a brush like paint. These products appeared on the market very shortly after the absorbent nature of a concrete block was recognised, and were offered as infallible remedies for this detrimental feature of concrete. Analyses made in the writer's laboratory have shown that in the greater number of cases these products contained nothing more than a low melting point paraffin or wax, fluxed back in a light volatile oil, and depending for their efficiency upon the deposition of the wax or paraffin in the pores of the concrete. We have found so-called waterproofings that contained within themselves over 95 per cent. of volatile constituents that acted purely as temporary solvents and carriers of the very small amount of solid base. It is quite unfortunate that the word "waterproofing" has been associated with these products, as it has naturally resulted in establishing doubt and scepticism on the entire subject. The trouble has been that insufficient investigation has been given to the character of the material to be used for such a product, and it is only within the last year or two that a few progressive manufacturers have given the necessary technical and careful scientific investigation to the subject and have been able to produce, by synthetic means, water repellent bases which show the maximum solution in volatile vehicles, and in two-coat work, to overcome the detrimental nature of porous surfaces. It is, therefore, encouraging to note that this small, but yet important part of damp-proofing, is being solved and satisfactory products are available.

There is a very distinct field for such coatings, as they are the only products which we have for treating the exterior surfaces of porous stone to preserve them from decay, due to the absorption of water and other atmospheric impurities which result, not only in the unsightly staining of the sensitive stone, but a general surface disintegration due to the disruptive force manifest by the expansion of the water in the pores on freezing.

Opaque Cement Coatings.—Nearly every cement user has practised coating his cement work with a plain cement grout, and has experienced the difficulty of obtaining a perfect bond and also has observed the tendency of the coating to absorb water. A few of the progressive manufacturers who have made a special study of the exact requirements of a concrete surface have produced coatings which are made up from a Portland cement base, and which show a perfect bond on the surface coated and are perfectly repellent and damp-proof. These products contain no oil and possess none of the characteristic qualities of oil paints. It is well known that an oil paint has no application to a concrete surface, as the vegetable oils used react with the alkali in the cement, forming a soap, and resulting in the disintegration of the coating. Oil paints also dry with a distinct gloss, which is very objectionable on a concrete surface, where the coating should retain the integrity and characteristic texture of the surface coated.

The cement coatings have a very general application for uniforming cement surfaces, such as stucco, cement blocks, etc., and replace the somewhat cheerless and unattractive surfaces with a soft-toned surface which is thoroughly damp-proof.

Special Bitumens.—The special bitumens differ from the products of the preceding classes in that they are not applied to the exposed surface, but to the interior of the exposed wall. Such products are black in appearance and are made up from the various selected waterproof gums. They are applied to the interior of a wall with a brush, and, besides providing a continuous membrane in the wall which will act as an insulator against the ingress of water, they provide a solid bond for a coat of plaster applied directly on the coating.

These products very obviously serve an economical purpose in eliminating the necessity of furring and lathing. By this construction the cubic area of available space is increased and all the disagreeable features of the air space are eliminated. Although the film is a fairly good non-conductor, it has not the same insulating efficiency as an air space, and is not recommended where the results would be unsatisfactory, due to serious condensation on the inner surface.

WATERPROOFING.

It is the present-day engineering practice to waterproof substructural masonry or structures designed to retain water by one of the two following methods, *viz.:*

(1) " Integral," or rigid method.
(2) " Membrane," or bituminous shield method.

Both of these processes have very distinct characteristic features and should receive very careful individual consideration.

According to the " Integral " method, a waterproofing compound is incorporated in the concrete mass, rendering same waterproof within itself. By the " Membrane " system the concrete work is insulated from contact with the water bv interposing a continuous, waterproof, bituminous shield.

The " Integral " Method of Waterproofing.—The " Integral " method involves the addition of a compound to the composition of the concrete as it is placed, and thus becomes a unit or integral part of the mass. The greater number of waterproofing compounds can be most simply divided into two classes, characterised by the physical condition in which they are added to the concrete, *viz.:*

(1) The finely powdered dry compounds that are added to the dry cement.
(2) The compounds, either in liquid or paste form, that are added directly to the water that is used to temper the dry mixture of cement and aggregate.

The compounds of the first class are usually homogenous, mixed with dry cement, in the proportions of 2 per cent. These compounds are chemically hydrated lime with a greater or less amount of the lime salts of fatty acids.

Necessity of Even Distribution of the Compound. — A careful study of the subject of " Integral " waterproofings will emphasise that the very first essential for successful results lies in obtaining an even, homogeneous distribution of the waterproofing compound. It is a chemical axiom that in any process endeavouring to produce a perfect mixture it is fundamentally essential that the body to be distributed must be of such a nature that it will be readily mixable with the distributing medium. On the basis of this fact, it is quite evident that the repellent properties, possessed by these dry compounds, are a considerable disadvantage in obtaining an even distribution. It makes very little difference how careful an original effort be made to dry mix a repellent compound with the dry cement and then with dampened sand: as soon as the water is added the repellent property of the compound will manifest itself, and as the fluidity of the concrete increases, the resistance to flow throughout the mass will decrease, and there will be a tendency for the repellent compound to expel itself from portions of the mass and be concentrated in other sections, thereby making an even, homogeneous deposition impossible. Although the repellent feature is an excellent property for a compound to possess when in place in the mass of concrete, its very nature makes the even distribution difficult, and thereby defeats its intended purpose.

Cmopounds Added Directly to the Water.—In the case of compounds that are added directly to the water, there is no difficulty in obtaining an even distribution, as thev have had the advantages of the water as a vehicle or carrier to evenly distribute them. As far as the homogeneous disposition is concerned, it should be quite evident that the compounds of the second class that are originally mixable with water have a decided advantage over the dry compounds of a repellent nature. An acceptable compound for this class of work should also contain no organic constituents or other materials that will in any way interfere with the strength of the concrete, as it should not be necessary to sacrifice strength to obtain waterproofing efficiency. A recent report of one of our Universities gave results which indicated a loss of over 50 per cent. in the strength of the concrete, due entirely to the presence of the emulsified oils contained in the compound.

The "Integral" method of waterproofing has a very general application to waterproofing conditions. It is only limited in particular cases when there is a liability for the continual development of cracks in the work, which would, of course, destroy the waterproofing efficiency. The "Integral" method is very universally employed for substructural work of various natures and to cisterns, reservoirs, etc., which are designed for containing water. The waterproofing compounds can be used throughout the mass of the concrete, or in cases where this procedure would be impractical, due to the cost of the waterproofing, it can be concentrated in a plaster coat on the surface of the structure. Rather than discuss fully the essentials necessary to be considered in applying the "Integral" method, I have briefly outlined below a typical specification showing the application of the "Integral" method of waterproofing in the form of a waterproof coat, as it should be used to correct the percolation of water into the basement of completed buildings:—

1. ***Intent.***—It is the intent of these specifications to correct dampness due to percolation of water through walls and floors in basements in buildings not properly waterproofed during construction.

2. ***Method of Procedure.***—Watertightness shall be secured by plastering the inner surface of damp walls and floor with an unbroken continuous coat of cement mortar to which as manufactured by has been added.

3. ***Preparation of the Coating.***—The waterproofed cement mortar shall be prepared by thoroughly tempering to required consistency a dry mixture of one (1) part of cement to two (2) parts of sand with water to which has been added in the proportion directed by the manufacturer. The sand shall be clean and spherical and well graded from coarse to fine.

4. ***Preparing the Surface to be Coated.***—Before plastering cement mortar on old concrete the surface of same shall be treated as indicated in the following:

(*a*) The old surface shall be cleaned very thoroughly with a heavy wire broom so as to remove all dust and dirt. A jet of steam shall be employed to clean the wall if available.

(*b*) To the mechanically cleaned surface apply with a large brush a liberal coat of 1 : 10 solution of hydrochloric acid. Allow the acid to remain until it has exhausted itself, which will require at least ten minutes. A second liberal coat of acid solution shall be applied before removing the first. A third coat shall be applied if the two applications have not satisfactorily exposed the aggregate and entirely removed the skin of hardened cement.

(*c*) With a hose, under good pressure, slush the surface in one direction so as to remove the salts resulting from the action of the acid. Continue the slushing until the salts and all loose particles are removed and the old concrete is thoroughly soaked to its full hygrometric capacity.

(*d*) To the cleaned and saturated surface apply with a strong fibre brush a coating of pure cement, mixed to the constituency of thick cream with water, to which has been added in the proportion directed by the manufacturer. Rub in rigorously so as to fill all the crevices and cavities produced by the action of the acid.

5. ***Application of Coating of Walls.***—Immediately after applying the above slush coat the first coating of waterproof cement mortar shall be applied (thickness, $\frac{3}{8}$ in.) directly upon the slush coating and well trowelled into every void or crevice of the surface. Before this first coat has reached its final set a second and final coat shall be applied to an equal thickness, so as to make the full average thickness $\frac{3}{4}$ in. The finish coat shall be floated to an even surface, and subsequently trowelled free from any porous imperfections. If the conditions of the work make it impracticable to apply finishing coat before scratch coat has set, the latter must be dampened and slush coated before finishing coat is applied.

6. ***Basement Floors.***—The floors shall be treated and prepared exactly as indicated above, and finished with the waterproofed mortar to a thickness of two (2) inches. Special care shall be exercised to bond the wall coating to the floor coating, so as to make the waterproof coat absolutely continuous.

The "Membrane" Method of Waterproofing.—This system of waterproofing differs distinctly from the "Integral" in that it does not attempt to treat the concrete but rather to insulate it from contact with water by enveloping the structure in a continuous bituminous shield. The fact that the "Membrane" is not a unit or rigid part of the structure permits a certain freedom of movement and action in the structure, without impairing the efficiency of the waterproofing. This feature of the " Membrane " system makes it most suitable for waterproofing work not fully reinforced and liable to settlement or subject to vibration or shock, such as railway bridges, culverts, etc.

It was early practice to simply coat the surface to be waterproofed with hot tar or asphalt, but it was soon evident that this was not sufficient, as the coating would crack with any movement in the wall. It was therefore necessary to employ some material in addition to the bitumens to contribute the necessary toughness and tensile strength. Burlap and coal tar felts have been extensively used for this purpose, and some very satisfactory waterproofing operations have been carried out with such materials. For the last few years considerably more attention has been given to the nature of the waterproofing felts, and as a result there are now on the market specially manufactured felts which are both saturated and coated with bitumen and possess greater pliability and strength. By means of these felts more perfect membranes can be constructed, as the strength and toughness of the felt permits greater distortion and twisting to accommodate it to the design of the work.

The bitumens most generally used for cementing the felt together in constructing the membranes are coal tar pitch, commercial asphalts and special asphalt compositions. Although coal tar pitch on account of its cheapness has been, and is still, being very extensively employed for waterproofing, there is considerable controversy among engineers regarding the relative value of the coal tar pitch as supplied to-day by the more modern methods of gas production and the older process in vogue when pitch was first used for waterproofing.

The asphalts are more suitable for waterproofing as they possess greater elasticity and permanence. In selecting an asphalt for waterproofing purposes special care should be taken to obtain a material of as low a melting point as the nature of the work will permit, as it not only insures greater elasticity when subjected to cold temperatures but works much more freely and easily in applying. The special asphalts are usually manufactured from a hard hydrocarbon, such as gilsonite tempered with petroleum residiums to impart the necessary elasticity. The residiums used in the preparation of these special asphalts should preferably be strictly asphalt bases, and contain the minimum percentage paraffin which, being of a lubricating nature, impairs the necessary binding properties of the asphalt.

The application of a bituminous membrane to any structure should have the same careful attention as any other important point of engineering design. Every job has its particular requirements, which should be carefully interpreted and the design fully suited to meet the individual conditions.

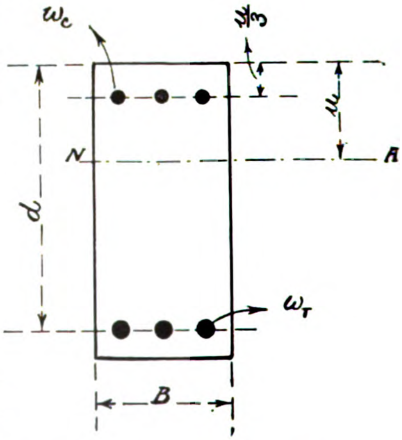
DESIGN OF RECTANGULAR BEAMS IN REINFORCED CONCRETE.

By JOHN C. GAMMON, B.Sc., A.C.G.I.

The article we are presenting on the design of rectangular beams should be of considerable interest, and we invite discussion on the subject as being one of importance.—**ED.**

THE diagrams accompanying this article give a quick and simple method of designing the rectangular beam as far as its resistance to direct stresses caused by bending is concerned. By means of them corresponding values of the breadth, depth, and reinforcement can be at once directly determined when the bending moment on the beam is known.

The diagrams are worked out according to what is usually known as the straight line theory, and in accordance with the recommendations passed by the Reinforced Concrete Committee of the R.I.B.A.



Two diagrams are shown. In one diagram the working stresses are 16,000 lb./in.^{2} in the steel, and 600 lb./in.^{2} in the concrete; in the other they are 17,000 lb./in.^{2} in the steel, and 600 lb./in.^{2} in the concrete.

The following abbreviations are used:

M = Bending moment.
B = Breadth of beam.
d = Effective depth of beam.
W_T = Tensile reinforcement.
W_C = Compressive reinforcement.
S = Tensile stress in steel.
C = Compressive stress in concrete.

Curves are drawn primarily, showing the relation between the bending moment and the area of steel required as reinforcement for various effective depths of beam. Next curves are drawn which denote the breadth of beam which is necessary in order that the stress in the concrete shall be that specified. In drawing these curves the assumption is made that corresponding values of B, d, and W_T are used for a given bending moment. If a greater value of B be used than is thus denoted, owing to the shear on the beam or to insufficient breadth for the disposition of the rods used as reinforcement, the concrete will be understressed, the length of the leverage arm will be altered, and W_T and d will have corresponding values slightly different to those given by the curves. This variation, however, is practically inappreciable.

The diagrams can be used not only when single reinforcement is required, but with a certain limitation when double reinforcement is also necessary.

SINGLE REINFORCEMENT.

The diagrams are used in the following manner. Having determined the bending moment on a beam the horizontal line corresponding to this value is traced to intersection with the curves representing various depths. Having chosen some depth, the corresponding value for the tensile reinforcement can be found by tracing the above intersection to the scale at the bottom of the diagram. It will be found that for given values of M and d a corresponding value for B is obtained by either working on or interpolating a value between the curves which have been drawn for values of $B=6$ in., 8 in., 10 in., 12 in., 14 in., 16 in., and 18 in. The value of B thus obtained will give the most economical breadth of beam to use; in fact, that breadth which is both necessary and sufficient from a consideration of the direct stresses in the beam due to the bending moment.

The following is an example of the use of the diagrams:

EXAMPLE.

M = 900,000 in.—lb.
S = 16,000 lb./in.^{2}
C = 600 lb./in.^{2}

The bending moment cannot, of course, be accurately determined until the size of the beam is known. It is assumed in this example that the above bending moment is the finally determined quantity corresponding to the chosen values of B and d. In practice, an allowance of 10 per cent. of the external bending moment can be made for that due to the weight of the beam. Values of B and d can then be found, and a second and more accurate determination of M and W_T can then be made. In the above example it will be seen from the diagram drawn for working stresses of 16,000 lb./in.^{2} in the steel, and 600 lb./in.^{2} in the concrete, that the following series of values could be used:

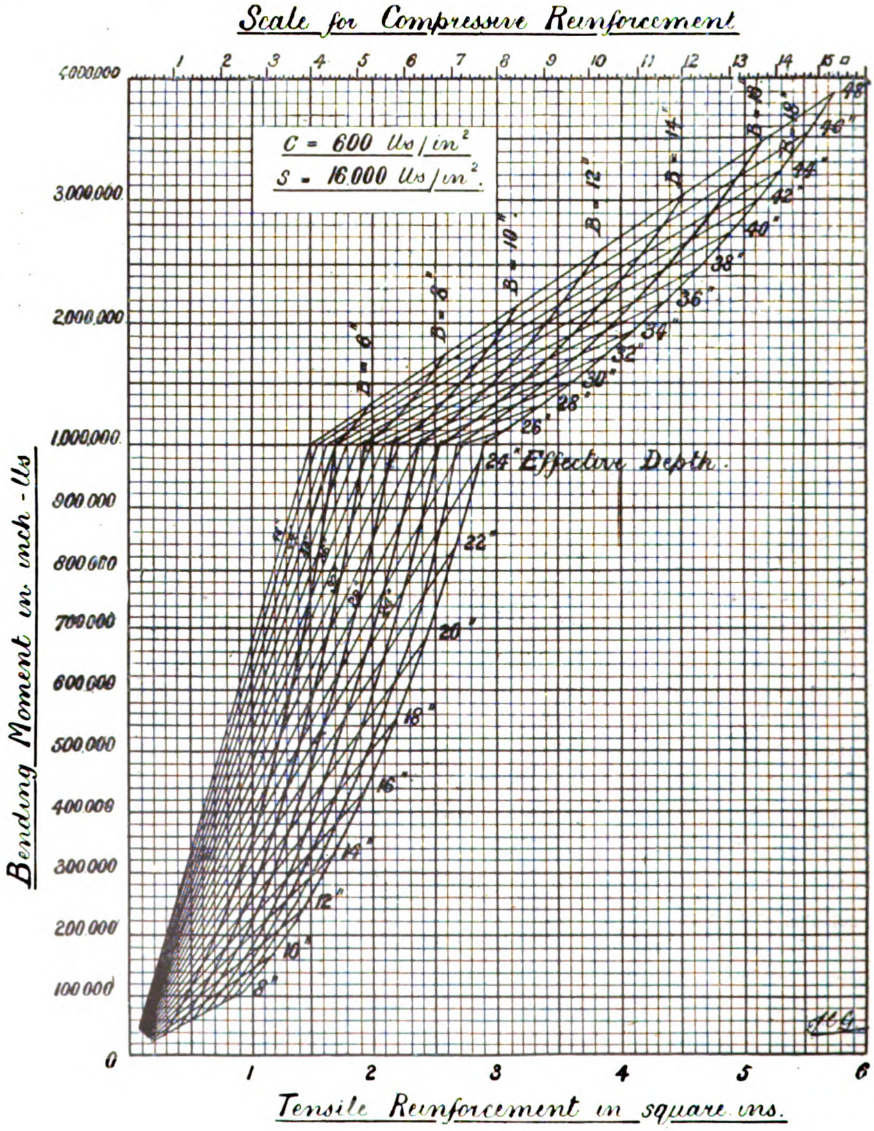
(1) $d=28$ in., $B=12$ in., and $W_T=2{\cdot}27$ sq. in.; or
(2) $d=30$ in., $B=11$ in., and $W_T=2{\cdot}12$ sq. in.; or
(3) $d=24$ in., $B=17$ in., and $W_T=2{\cdot}64$ sq. in., etc.

Knowing the effective depth of the beam, the total depth of beam can be settled when the amount of covering and the size and disposition of the reinforcement rods are known.

DOUBLE REINFORCEMENT.

On the assumption that any compressive reinforcement which may be required is placed at the centre of compression of the concrete, these curves may also be used for determining any double reinforcement which may be necessary. In the first place, the leverage arm of the tensile reinforcement will be unchanged, and therefore it will be possible to find W_T in the same manner as that described above. Thus, having decided on the maximum values which can be given to B and d, the value of W_T corresponding to a given bending moment is first found, the value of B being ignored.

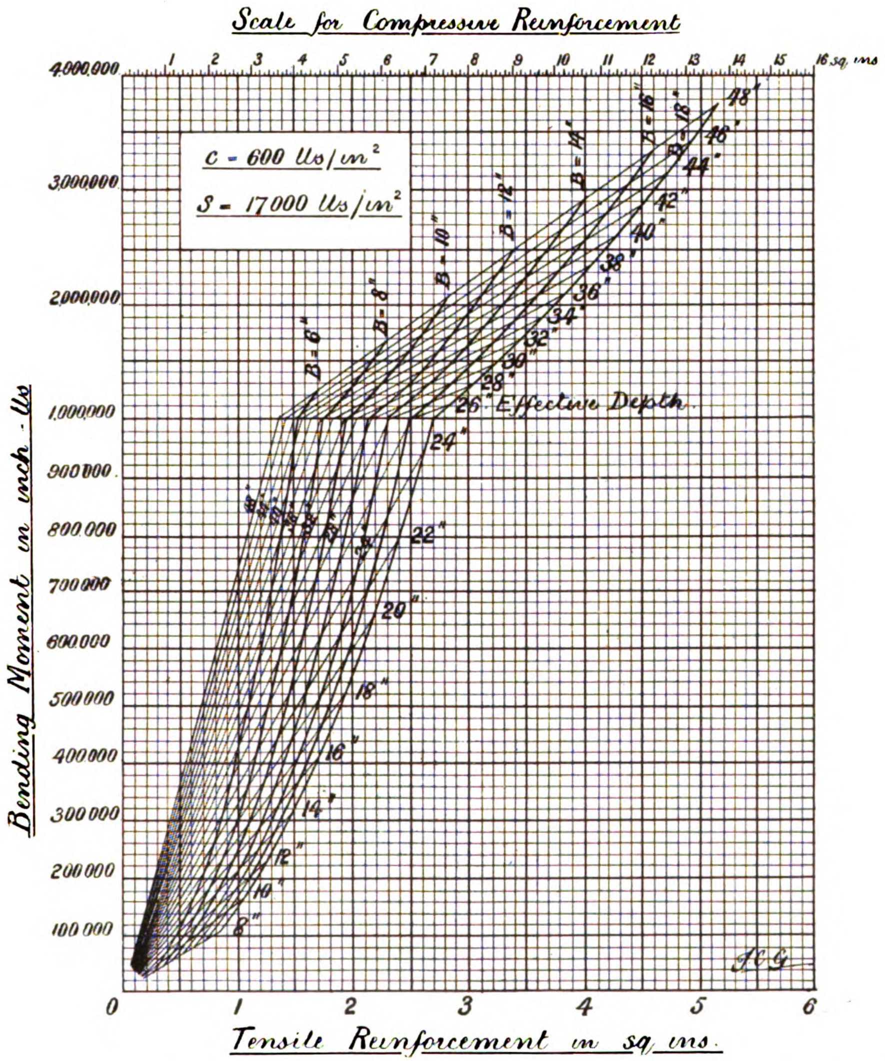
Secondly, the bending moment which can be taken by the concrete can be found for the given values of *B* and *d*. The difference between this amount and the total bending moment gives the bending moment which must be taken by the compressive reinforcement. The horizontal line corresponding to this



value is traced to intersection with the curve representing the given effective depth, and this intersection is traced vertically to the scale at the top of the diagram. This scale will give the amount of compressive reinforcement which is required. The following is an example:

EXAMPLE.

M = 2,000,000 in.—lb.
B = 12 in.
d = 36 in.
c = 600 lb./in.^{2} } Working stresses.
s = 16,000 lb./in.^{2} } Working stresses.



It will usually be most economical to use the greatest effective depth possible with the purpose of avoiding as far as possible double reinforcement. The steel placed in compression is much less economically used than the tensile reinforcement. It is assumed in this example that the choice of the above values of B and d has been determined from practical considerations.

From the diagram it is seen that the value of W_T corresponding to values of $M=2,000,000$ in.—lb. and $d=36$ in. is 3·98 sq. in. The bending moment which can be taken by the concrete in compression in a beam of 36 in. effective depth and of 12 in. breadth is seen to be 1,460,000 in.—lb. There is, therefore, a bending moment of $(2,000,000-1,460,000)=540,000$ in.—lb., which must be taken by reinforcement to be placed in the compression area of the concrete. Using now the top scale of the diagram, it will be found that 2·85 sq. in. of steel are required in compression to take this bending moment.

In general practice the metal in compression will be placed rather nearer the compression face of the beam than it would be if it were placed at the centre of compression of the concrete. If this be the case, owing to the slightly increased length in the leverage arms of the tensile and compressive reinforcements, the beam will be slightly stronger than calculated.

In using these curves, if for a given value of M and h it is found, say, that B should be 10 in., and if a value of 12 in. be used, then it is approximately true to assume that the concrete is being stressed to 10/12 of its permissible value. Therefore, if it were desired to use the curves for a working stress in the concrete of, say, 650 lb./in.,^{2} it would be approximately true to use the curves drawn for a working stress in the concrete of 600 lb./in.^{2} and multiply the value of B obtained by $\frac{600.}{650}$ The fundamental error made in this approximation is the neglect of the change in the position of the neutral axis caused by a variation in value of the ratio of the stresses in the steel and the concrete.

RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS.

STRUCTURAL ECONOMY.

Paper by E. A. SLATER, F.S.I., A.M.I.C.E. (Graduate).

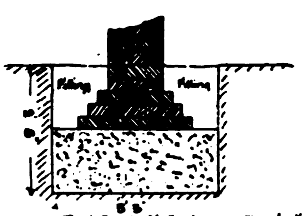
Mr. E. A. Slater, F.S.I., Assoc.M.Inst.C.E. (Graduate), read a Paper on "Structural Economy" before the Incorporated Association of Municipal and County Engineers, at a meeting held at the Agricultural Hall, Islington, on May 11th.

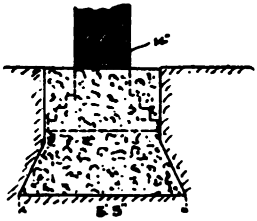
It should be the aim of engineers to effect economies in construction; not so much in initial cost: if this only were studied the result would not be economical; but in initial cost plus maintenance over a considerable period of time, say fifty years for permanent structures. It must be explained at the start that the prices given here cannot be expected to be universally applicable, but are believed to be approximately right for districts such as the East of England, where bricks, gravel, or aggregate for cement, are plentiful, but building stone scarce. No methods are suggested that have not been adopted by the writer in practice and tested by time; he believes he can show how economies can be effected, without reducing, but rather increasing, the strength and durability of the structure.

Foundations.—Commencing at the bottom of the building, *Fig.* 1 shows text-book construction for foundations, *Fig.* 2 an alternative. In *Fig.* 2 the trench is dug to depth required to get to a sound bottom, the labourer goes along with a spade and undercuts to an angle of 60° or thereabouts, and then the trench is merely plugged up almost to ground level with cement concrete, and all brick footings are discarded. It may be urged that this is not in accordance with the wording of the model by-laws, but the by-laws do not say that the footings shall be constructed of bricks; they ask only for the foundation shown by the dotted lines in *Fig.* 2, three courses of footings for a 14-in. wall; the alternative construction merely substitutes cement concrete or artificial stone for brickwork (and it must be remembered that cement concrete is stronger than brickwork), with the additional thickness of the part outside the dotted lines; the greater includes the less, and the spirit of the law which asks for a certain minimum of strength is therefore not contravened.

It is not generally recognised that brick footings are now superfluous; when the model by-laws were written, cement was too dear for ordinary building construction, and brick footings acted as a protection against the crushing of lime concrete, which is all the more likely to occur when the lime is softened by moisture; but cement concrete, being capable of standing greater loads than brickwork, requires no such protection, the bricks themselves would crush before the concrete.

The saving effected will, of course, vary with local conditions, but will be practically about 25 per cent., and will be accompanied not by a reduction but by an increase of strength and durability. There will be no mortar joints to be dissolved by

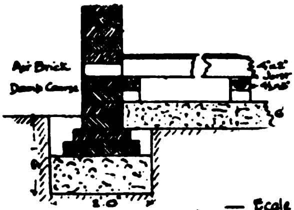


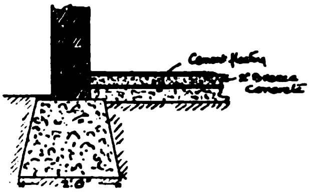


Text Book Method — Scale ¼" = 1ft —

— Fig. 1. —

— Fig 2 —

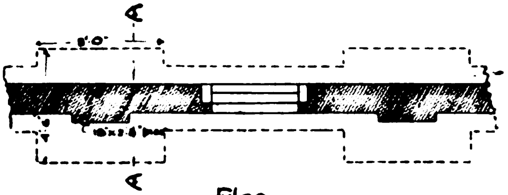




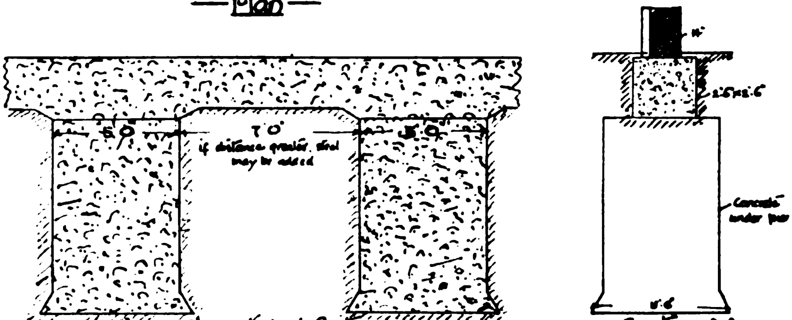
Text Book Method — Scale ¼" = 1' —

— Fig 3 —

— Fig 4 —



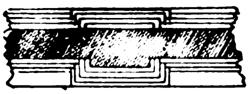
— Plan —



— Longitudinal Section —

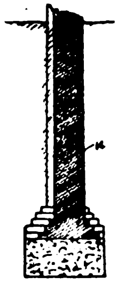
— Section AA —

— Fig 5 —



— Plan —
Text Book Method

Scale ¼" = 1ft

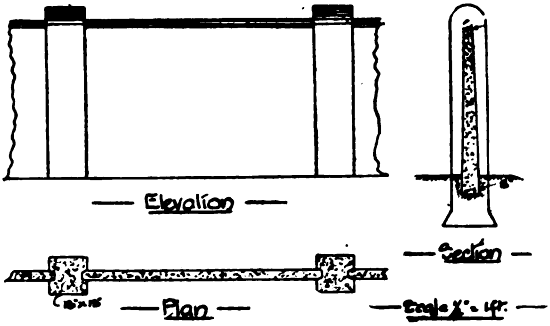


— Fig 6 —

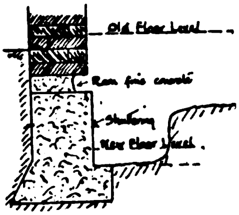
— Section AA —

moisture, and the greater depth of concrete will give great longitudinal strength, acting as a continuous girder bridging over defects and variations of bearing power of the subsoil, which must be more or less an unknown quantity.

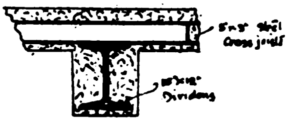
As applied to cottages on good soil, see *Figs.* 3 and 4, the builder, just by bevelling his trench slightly, will save about 25 per cent.; the cost per foot run working out at 1s. 8d. and 1s. 3d. respectively.



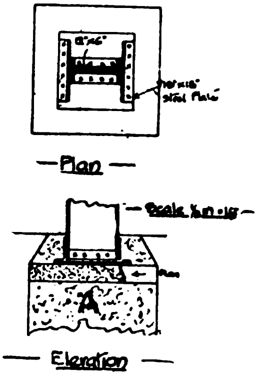
—Fig 7—



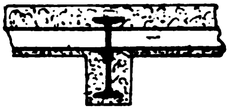
—Fig 8.—



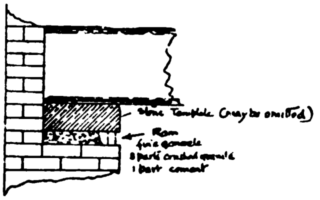
—Fig 11—



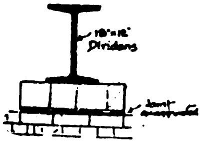
— Fig 9 —



—Fig 12.—



—Fig 10—



—Fig 10 a—

The saving is greater really than shown by these figures, which are based on equal bearing areas, because, with the additional longitudinal strength, we can base calculations on average resistance of soil, and with the old method an isolated spot may cause a settlement.

Similar economy will be effected in the application of this principle to heavy structures with deep foundations, see *Figs.* 5 and 6.

Suppose that we are dealing with a warehouse or public building of several stories, with heavy concentrated loads due to girders carrying concrete floors. The pier construction should be adopted, girders arranged to come one over the other on to piers which will also carry the roof trusses, spaced at anything from 10 ft. to 15 ft. centres; then, instead of taking the whole length of walls down, holes could be sunk where the piers occur, just large enough for convenient digging, and the concrete between piers, which carry comparatively little weight, can bridge across the loose soil and be calculated as independent girders. A load of 50 tons is allowed for in this case on the pier and panel, and safe bearing load on the deep foundations assumed at 1½ tons per sq. ft.

It will be seen that merely by under cutting, the bearing area is increased from $5' 0'' \times 4' 6'' = 22\frac{1}{2}'$ to $6' 9'' \times 5' 6'' = 33'$, or 50 per cent. increase of bearing surface with only a 2 per cent. increase of material.

Taking brickwork at £14 per rod, concrete at 12s. per cu. yd., excavation at 3s., and allowing for extra cost of blue bricks to piers, the saving works out at £3 10s. for the 12-ft.length (or as 2 is to 3); but the chief advantage lies in the distribution of the pressures on the subsoil—the increased bearing surface is obtained where the load is, where it is wanted, under the piers, and the more costly method would not even be safe, because of the difference in intensity of pressure on the soil under the pier and under the panel. An inverted arch is really required which would still further increase the difference of price.

Construction of Walls.—The writer may be called a concrete maniac, but he does not go so far as to advocate concrete for the walls of the ordinary dwelling-house. Where engineering strength or durability is required, we know that brickwork cannot compete for price and efficiency with concrete or reinforced concrete. There are other things, however, besides mere strength that must be considered, and there is no material in existence to beat brickwork for non-conductivity, pleasing appearance, and convenience of erection. But improvement can be made in the method of jointing. It does not seem to be generally realised how the cheapness of cement alters the conditions, so that it is now more economical to use cement than lime for mortar. Just in the same way as with cement concrete we are able to do without footings, so with cement mortar we can break all the rules of bond with impunity, simply because the matrix is stronger than the aggregate, and the thicker the joints the stronger the wall. Where bricks are porous, which is usually the case, and walls only 9 in. thick, there is a serious objection to the usual method of bonding: the headers carry the wet right through the wall. For small houses the usual hollow wall construction, two thicknesses of stretchers with a cavity, gets over the difficulty satisfactorily and is quite strong enough for ordinary purposes with cement mortar, hardly so with lime mortar. But where greater strength is required, combined with exclusion of damp, the construction shown in *Fig.* 4 is to be recommended, and makes a waterproof wall of great strength. The two half-brick thicknesses are carried up, perhaps to a height of 10 ft. at a time, leaving a cavity about ¾ in. wide, which is filled up with liquid grout, 1 part cement to 1 or 2 of sand. The danger of bulging under liquid pressure may be avoided by keeping the grouting level a little below that of the top of brickwork, until the joints have had time to set. This grouting not only provides a watertight vertical layer, but it forces, under pressure, into all the spaces and frogs, binding the whole together as one solid rock.

Walls.—Concrete, though unsuitable for walls of buildings for the reasons stated, will probably come a little cheaper than brickwork for boundary walls, where strength is essential, as for schools and corporation yards, etc. The writer has adopted the construction shown in *Fig.* 7. The grooves shown in the piers are easily formed by inserting planed and bevelled upright members in the frames, and the idea is that should shrinkage occur the panel will be drawn slightly out of the groove, preferably to developing an unsightly crack in the panel. Certainly, no cracks have appeared, but whether that is due to this device it is difficult to say. The dimensions shown would be excessive in most cases, but this wall had to be particularly strong. As the cost of concrete, including the shuttering, was no more than that of brickwork and the thickness of panel only about 6 in. against the 9 in. that would be required for a brick wall, and the cost of a separate coping is avoided, it is evident without further analysis that a saving can be effected. Again, on a fifty years' test, this form of wall is vastly cheaper than an open wrought-iron fence, for the total expense of painting, say fifteen times in this period, will in all probability mount up to more than the initial outlay.

Underpinning.—The orthodox way of underpinning to an existing wall is to put brickwork in cement abutting immediately under the existing work to be supported, and tightening or filling up the inevitable space between the new and old work by driving in slates. A more satisfactory method is shown in *Fig.* 8. There can be nothing simpler: concrete is filled in up to 3 in. or 6 in. of the existing work, and allowed to set. Fine cement concrete is then rammed or actually hammered into the space that is left, which should be only just deep enough to allow room for ramming conveniently; to ram effectively the bulk of concrete should not be great.

Foundations to heavy stanchions may be dealt with in a similar way, see *Fig.* 9. The concrete A would be put in first and allowed to set, the stanchion erected in position on small blocks, and then the fine concrete hammered in as before. So also, concrete can be rammed under the ends of heavy girders on walls or under the stone templates, if templates are used. It will be noted here that in *Fig.* 10 the pier is shown to be built in brickwork; but wherever a large pier is required, a better plan is to build it up hollow with a 4½ in. shell or casing, and when this is set, to fill up the hollow from above with fine concrete. *Fig.* 10*a* shows what is apt to occur with the ordinary method of bedding a large template. Only by the ramming method can we be sure of absolutely tight contact between the whole area of the steel or template with the work below; at the same time it is the cheapest and easiest way out of the difficulty. The writer has, by this single operation, underpinned and provided an efficient damp course to old buildings which were damp and cracked, merely by knocking out one or two courses of brickwork all round and ramming in concrete composed of two or two and a half parts of ¼-in. granite chippings to one part of Portland cement, the same concrete course forming the joint between the old brickwork and new concrete pier foundations, sunk at intervals.

In the laying of tramway rails we get a familiar illustration of the same principle which has been often but not universally adopted. The tram rails are supported in their required position on blocks and the concrete rammed horizontally under as well as around and above the flange, all in the same gauging. This is a sort of reinforced concrete construction. The close contact and grip of the concrete with the steel prevents movement either downwards or springing upwards, and the frictional resistance of the areas of surface in contact is sufficient to prevent expansion or contraction under variations of temperature.

Ground Floor Construction.—*Fig.* 3 gives a typical text-book arrangement with a cement concrete layer as required by the model by-laws, and *Fig.* 4 a suggested alternative. It is rather curious that it is considered quite correct to lay wood blocks directly on to concrete for ground floors, but that if we do not wish to cut the wood into little pieces, we are supposed to have all the paraphernalia of joists, wall plates, sleeper walls, and air bricks. The writer has, however, been laying floors for many years as shown in *Fig.* 4. First a layer of good concrete 4 in. thick, say five parts shingle to one cement, with plenty of sand, floated over in cement and sand and one to bring to a watertight surface, then 2 in. breeze concrete, five or six to one, on which the boards, tarred on either side, are nailed direct; the cement is laid as early as possible after the commencement of the building, so as to allow plenty of time for setting and drying before the boards are put on.

The economy of this method in initial cost is obvious at first sight. This construction is suitable for public schools, and if the boarding is in narrow widths, it is just as effective as wood blocks and considerably cheaper.

Upper Floor Construction.—This is where the reinforced concrete man comes in, but the writer does not wish to enter into a discussion of the various patents. The construction in *Fig.* 11 is not so general as *Fig.* 12, but saves all the expense and bother of holing and riveting and cutting to exact lengths, and the cross girders running through in continuous lengths are more efficient; it is merely working on the general principle that the main supporting member should be underneath the work that it supports. There is no loss in height, as the average height of the rooms practically goes up to the panel level; the projection of the girder below the ceiling is not objectionable but lends itself to ornament. For very large spans, it may sometimes pay to use plate girders, on account of being able to vary the amount of metal from the centre to the supports, but this would be an exceptional case in building construction.

Drains.—Just one more instance of the use that may be made of the cheapness of cement. Cast-iron pipes are often recommended where the best work is required for drains, but G.S. pipes, encased in cement concrete, can be made equally watertight and cost less initially; they will last longer and retain a smooth surface while the iron pipes are corroding.

Cement for Flats.—There is another case in which the cheapness of cement should influence construction. The lead flat should now be a thing of the past, for the lead costs about 15s. per sq. yd. without joists and boarding, whereas asphalt and concrete included can be done for 10s., and is more durable, permanently watertight, and fireproof, than the lead flat.

DISCUSSION.

Mr. A. E. Collins (Norwich) said the paper was one which gave rise to thought, and impressed the fact that in designing work one ought to use one's brains, and not to be satisfied to do a thing because most people had done it the same way. As a matter of fact, nowadays, a good deal of design was a matter of pure memory. It seemed to him that there should be reason applied in all design, and not slavish copying, although if they could not see their way to improve on what had gone before they would be foolish to alter it. With regard to the details in the paper, if they took the question of underpinning, a number of people attempted to get a mass of concrete tight under the wall to be supported, but it was impossible if the work had to be done in the way the author pointed out. He moved a vote of thanks to the author.

Mr. Alford (Southend), in seconding the motion, said the paper would be of the greatest value as a book of reference rather than as a subject for discussion. It was a mass of detail which required consideration as one came across work to which it was applicable. He thought they would bear the paper in mind, and have reason to thank the author from time to time.

UNIVERSITY OF LIVERPOOL ENGINEERING SOCIETY.

REINFORCED CONCRETE IN WATERWORKS ENGINEERING.

Paper by HAROLD J. F. GOURLEY, B.Eng., Stud.Inst.C.E.

The following is a summary of the Presidential Address on "Reinforced Concrete in Waterworks Engineering," delivered by Mr. Harold J. F. Gourley, B.Eng. Student President, at a recent meeting of the University of Liverpool Engineering Society.

Generally.—The use of reinforced concrete in waterworks engineering was quite a recent development in this country, although it had been used in Canada and the United States for a number of years, and had been adopted on the Continent, principally in France and Germany, for some time. The question naturally arose, Why are we behind the countries named in taking up the use of reinforced concrete? In the first place, there had been considerable difficulty in obtaining loans to cover the cost of reinforced concrete structures for any reasonable period with the sanction of the Local Government Board, but the fact that in the new War Office and new General Post Office, London, reinforced concrete was used to a considerable extent indicated a certain inconsistency in the attitude of the Local Government Board.

In the secnd place, there was still a prejudice amongst some engineers against its use. Of course, it was a comparatively new material, but it had stood many severe tests in other countries, and the precise ground of objection to it was rather hard to find. And then, too, it was sometimes said that the designer of a reinforced concrete structure would have difficulty in justifying the correctness of his design were he called upon to do so, as the methods of calculation and the assumptions made were still the subject of much controversy. To this he would say that the theory of reinforced concrete design to-day left no loophole for uncertainty, and had been endorsed by eminent bodies of engineers both in Europe and in America.

Others still had doubts as to the value of concrete as a protection against corrosion, and as regards the bond between the metal and the concrete.

Concrete as a Protection Against Corrosion.—Whilst time would not permit an exhaustive consideration of these objections, it might be mentioned that quite a number of engineers had made experiments bearing on these points, a common procedure being to embed rods of metal up to, say, 1 in. in diameter in small blocks of concrete of varying constitution, and to note the appearance after being embedded, say, three months, during which time the concrete had been subjected to varying external influences as compared with the original appearance of the metal. The results of these experiments showed that where the concrete was of a suitable character and the metal well embedded the results were quite satisfactory. Experiments of this kind would yield more instructive and convincing results if they were carried out on a larger scale over longer periods and under more practical conditions. In practice it was not merely plain rods which were to be surrounded with well-compacted concrete, but more frequently a miscellaneous collection of metal offering considerable difficulty to the workmen who had to get the concrete into place. Speaking of deterioration brought to mind a case in which some steel chain had been embedded in a concrete sea wall as reinforcement for twenty-five years, and which, when exposed quite recently at Bridlington, showed no signs whatever of corrosion, although the lower half of the wall had been covered by the sea at every tide. Numerous experiments, too, had been made to determine the magnitude of the ultimate adhesive stress between metal and concrete for different proportions of concrete and for varying conditions in the surface of the metal. These results had shown that for plain rods an ultimate stress of 650 lb. per sq. in. at three months was not exceptional. The value used in design, which varied from 60 lb. to 100 lb. per sq. in. with different authorities, gave an ample margin.

Materials.—Before passing on to point out the advantages claimed for reinforced concrete the various materials of which it is composed should be considered. The sand should be clean, coarse and sharp. The presence of clay or loam in sand in any considerable proportion rendered it unfit for use. The shingle or broken stone used must be of a hard, close-grained quality and perfectly clean. The sand, if any, in this material should be screened out. The stones should be varied in size, but the maximum size allowable depended entirely on the size of the concrete members. In small beams, slabs and columns ¾ in. might be the maximum diameter, but 1¼ in. or 1½ in. might be allowable in larger members. The stone and sand must always be gauged separately. It was most unscientific and unsatisfactory to go to some trouble to carefully determine the proportions of a concrete, and specify accordingly and then, as was sometimes done, to allow a mixture of the two to rank as equivalent to the separate gaugings. The cement should fulfil the British standard specification, and for this class of work must be thoroughly aerated before use in properly constructed sheds. For parts which were subjected to any pressure of water the proportions of the concrete would be 1 of cement, 2 of sand, and 3 of stone, or as is the more modern and scientific method of specifying, 770 lb. cement, 18 cub. ft. of sand, and 27 cub. ft. of stone. In other parts, such as the roofs of reservoirs and tanks, a 1 : 2 : 4 mixture was generally used. The mixing should be done in a batch mixer, and after finding the quantity of clean water which gave a rather wet mixture, this quantity should be strictly adhered to afterwards. The aim in concrete making, particularly in reinforced concrete work, should be to get absolute uniformity throughout. The working stress allowable for concrete in compression was about 600 lb. per sq. in. for pieces subjected to bending, and 500 lb. per sq. in. in columns, and in shear 60 lb. per sq. in.

Reinforcement.—Regarding the reinforcement, this was now usually mild steel, but when welding was necessary wrought iron was the safer metal to use. The working tensile stress for steel was about 16,000 lb. per sq. in., and about 11,000 lb. per sq. in. for wrought iron stirrups, joists, or straight or twisted steel bars. As to the amount of reinforcement usually provided, in a simple beam the percentage of the whole area of beam section taken up by the metal would not greatly exceed 1 per cent. on the tension side—anything above 1 per cent. was usually provided for by using metal in the upper portion of the beam, which was not economical, since such extra metal can carry only about half the working stress of the metal in tension. A slight rust film on the metal was not objectionable; in fact, it was an advantage, but any loose scale rust or oil should be removed, as it tended to destroy the adhesion between the metal and the surrounding concrete. As regards the amount of cover necessary, some authorities gave a minimum of $\frac{1}{2}$ in., but this evidently referred to beams and the like. Probably for waterworks structures, in particular those actually in contact with water, the minimum would be 1 in. to $1\frac{1}{2}$ in.

Advantages of Reinforced Concrete for Reservoirs.—The advantages of using reinforced concrete in reservoirs, tanks and filter beds were as follows:

(*a*) *It was more economical.*—The roofs, walls and floors were of very much lighter construction than if constructed in concrete or masonry. For reservoir bottoms in bad ground it was much more reliable and less costly than the ordinary methods of construction. The cost of a reservoir built entirely of reinforced concrete was 14 per cent. to 15 per cent. cheaper on the average than one of equal capacity built of mass concrete or brick or of a combination of both.

(*b*) The cost of maintenance was practically *nil.* This was also true, of course, of an all-concrete structure.

(*c*) Works in reinforced concrete could be constructed very rapidly, due to the simple character of the materials employed. In this very rapidity lay the possible danger of giving too much attention to "speeding-up" the work and too little to efficient supervision.

(*d*) It was generally conceded that reinforced concrete had a high hygienic value.

(*e*) By using reinforced concrete in a reservoir very much less material was used, and consequently less space occupied.

(*f*) The reservoir increased in strength with age. This was an important consideration: other materials deteriorated, whilst concrete increased in strength with age.

(*g*) A reservoir built of concrete or reinforced concrete throughout, or a combination of both, had no joints, and repairs were readily made if required.

As in all other branches of engineering, great care had to be taken in designing the various structures so that they were strong enough to stand all the possible conditions of loading.

Reinforced Concrete Aqueducts.—The advantages mentioned regarding reservoirs applied equally well to aqueducts. Reinforced concrete conduits also had this advantage over concrete or masonry structures; they could be, and they had been, subjected to internal pressure due to water under a head. Before the expanded steel was used as a reinforcement in certain portions of the Birmingham aqueduct, the engineer had a series of tests made on 4 to 1 concrete slabs, 6 in. thick. Without the expanded steel the uniformly distributed breaking load was 4 cwt. per sq. ft., and when reinforced with expanded steel 3 in. mesh, $\frac{1}{4}$ in. by $\frac{3}{16}$ in. strands, the load was 20 cwt. per sq. ft., which showed marked advantage due to the reinforcement. Reinforced concrete had also been found suitable for high-pressure water mains, and it was likely to be largely used for this purpose in the future, particularly as no corrosion could take place in such pipes, whereas in cast iron pipes and steel tubes this was a serious matter. For heads up to 40 ft. or 50 ft. reinforced concrete dams had been used to a large extent in the States, particularly for power schemes, and there was one now under construction there having a height of about 140 ft., and three or four others of similar magnitude are just about to be built. Amongst some of the advantages possessed by that type of dam he would mention:—

(*a*) There was practically no danger that the dam would be swept down stream, and absolutely no possibility of the dam being overturned.

(*b*) The hydrostatic pressure, acting up, which reduced the stability of a solid masonry dam was totally absent.

(*c*) The strength increased with age.

(*d*) The time required for construction was considerably less than for other methods.

(*e*) The crushing strength of massive masonry was a somewhat uncertain quantity, and therefore low unit values were adopted for working stresses whenever crushing strength became a factor in the design. In the case of the reinforced concrete structure, the stresses on every part of the structure were quite definite, and the engineer could not only tell exactly how much stress would be found in each part, but he could also design the work with any desired factor of safety.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course o construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

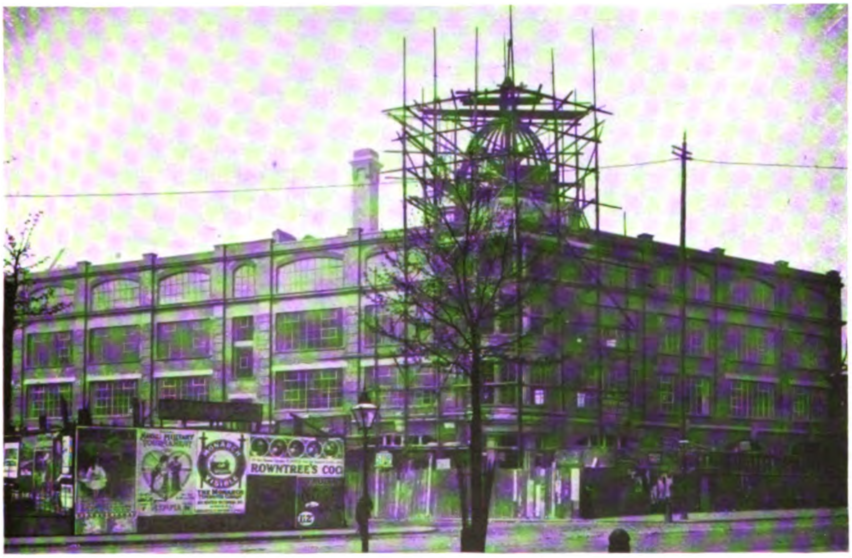
REINFORCED CONCRETE TOBACCO FACTORY.

THE new tobacco factory which has recently been completed for the firm of Carreras and Marcianus Cigarettes, Limited, in the City Road, is a building in which the characteristic constructional qualities of reinforced concrete, namely, its economic and expeditious construction, have been very forcibly exemplified.

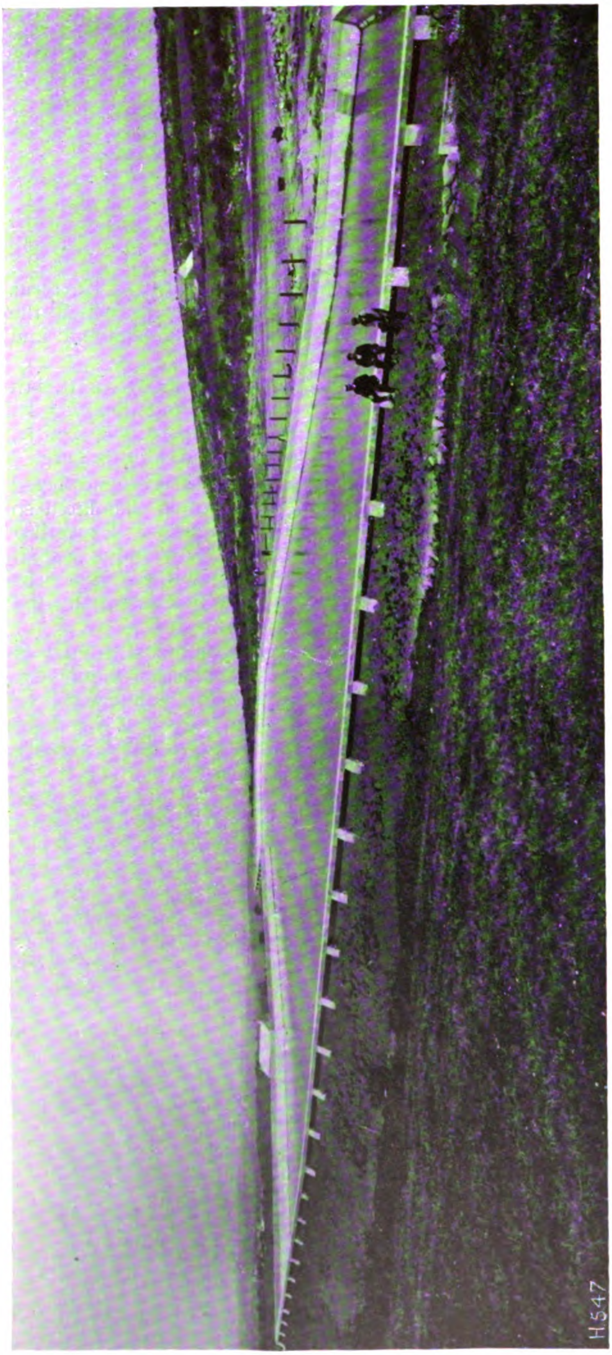
Its frontage to the main road is comparatively small, being only about 90 ft., but the building extends back for a distance of from 200 ft. to 250 ft., being about 55 ft. wide and having two wings, bringing the total width at each end up to about 70 ft. The premises cover an area of 11,395 sq. ft., or rather more than a quarter of an acre.

Besides the basement, there are four floors and flat roof, the latter being protected by parapets, thus making it suitable for storage purposes. The roof is calculated so as to act as a floor in case of future extensions which may be considered. Excepting the enclosing walls, the work has been entirely constructed on the Hennebique system of reinforced concrete, which includes the floors and roof, columns from basement upwards, all stairways and landings, two suspended van roads over the basement, and a flat roof over the boiler-house.

The proprietors, after comparison of the cost of reinforced concrete with that of ordinary construction, decided on the former as being the most economic scheme for adoption, both on account of its being lower in initial cost and also the shorter time necessary for completion, which was an important point to be considered in this case. Other advantages accruing from this decision are the superior rigidity



TOBACCO FACTORY FOR MESSRS. CARRERAS & MARCIANUS



The new Camborne Waterworks.

of the building, its absolute immunity from fire, and the absence of annual upkeep.

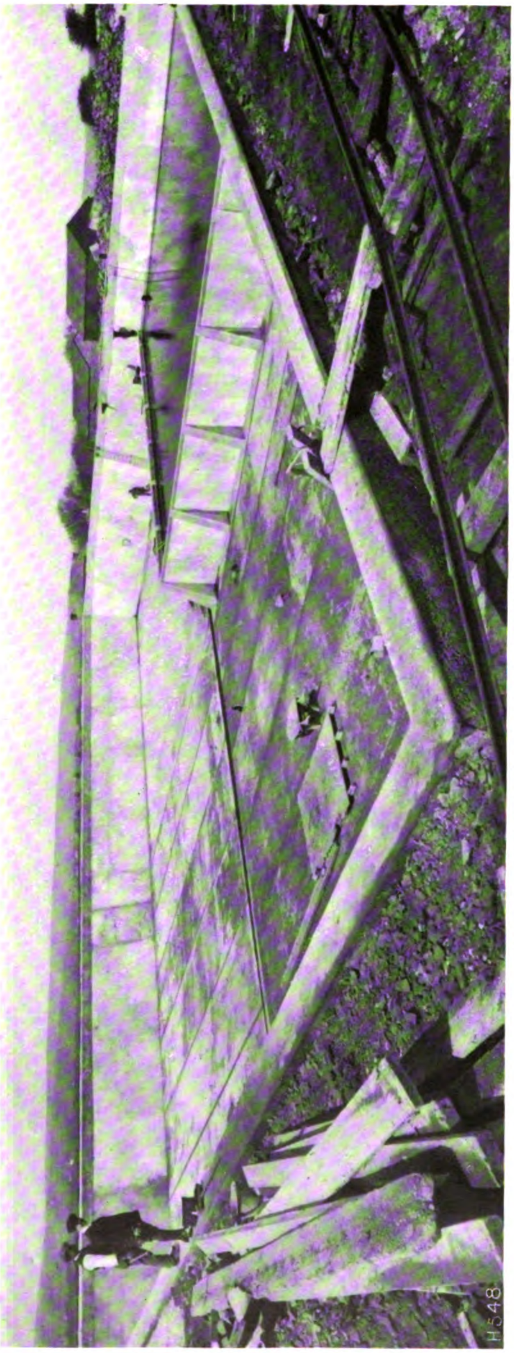
A good idea of the expeditious progress made by the contractors may be gathered from the statement that the timber moulds and centering for the basement columns and ground floor were commenced on January 3rd last, and that by March 15th the roof was completely finished.

As each storey includes about 11,200 sq. ft. of reinforced concrete flooring, in addition to twenty-one interior columns, two staircases and two lift wells, the amount of work is very considerable and its execution at the rate of fourteen days per storey deserves special notice by architects and others interested in building construction.

The structure was designed by Messrs. Hobden and Porri, of Finsbury Square, E.C., the general work having been executed by Mr. H. Kent, of Lewisham, and the reinforced concrete construction by Messrs. Holloway Bros. (London), Ltd.

THE CAMBORNE NEW WATERWORKS.

The Camborne (Cornwall) Water Company have, during the past two years, carried out a scheme supplemental to their original works of storage and distribution, not only in result of insufficiency of storage, but of the intermittence of supply to two suburban areas of high level.



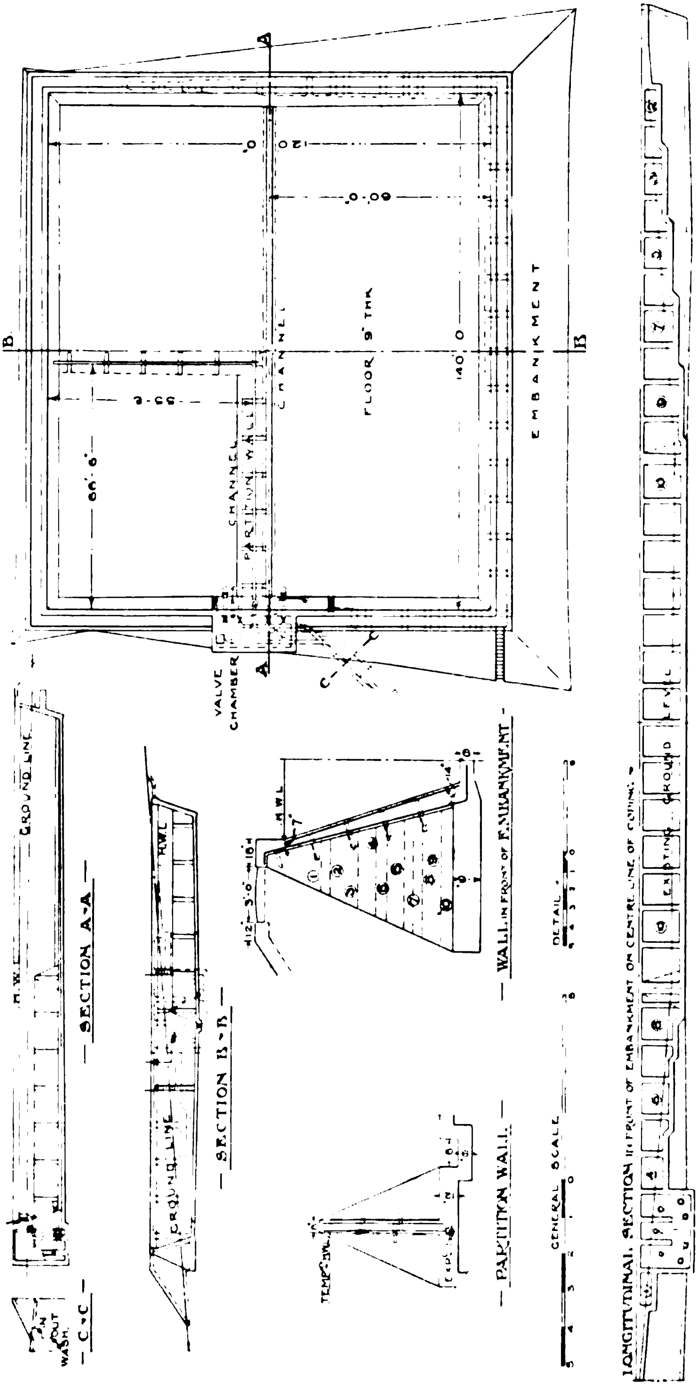
THE NEW CAMBORNE WATERWORKS IN COURSE OF CONSTRUCTION.

The district of supply having, until the recent incorporation of the new works, been supplied direct from the trunk mains from the storage works (four and a half miles distant), the hydraulic gradients rose and fell throughout the entire length of mains, with the variation of draught, with the result that, at times of maximum draught, the gradients steepened to such an extent as to fall below the high level areas.

To overcome this a service reservoir of 1,000,000 gals capacity has been constructed as near to the town as the necessary top-water level permits. This reservoir now being supplied from the storage works equally throughout the day and night on the average gradient, the variation extends only over the system of distribution mains.

For a source of supply in addition to that from three storage reservoirs, the company, some few years back, drove adits through land owned by them on an adjacent catchment area. Upon this land a new reservoir of 4,000,000 gals. capacity has been constructed for the storage of water yielded by the streams and that amount from the adits over and above the draught.

The considerable depth to the non-fissured rock below the ground surface and the absence of suitable local clay for puddling led to the adoption of concrete throughout the construction of this reservoir, the design of which has been a

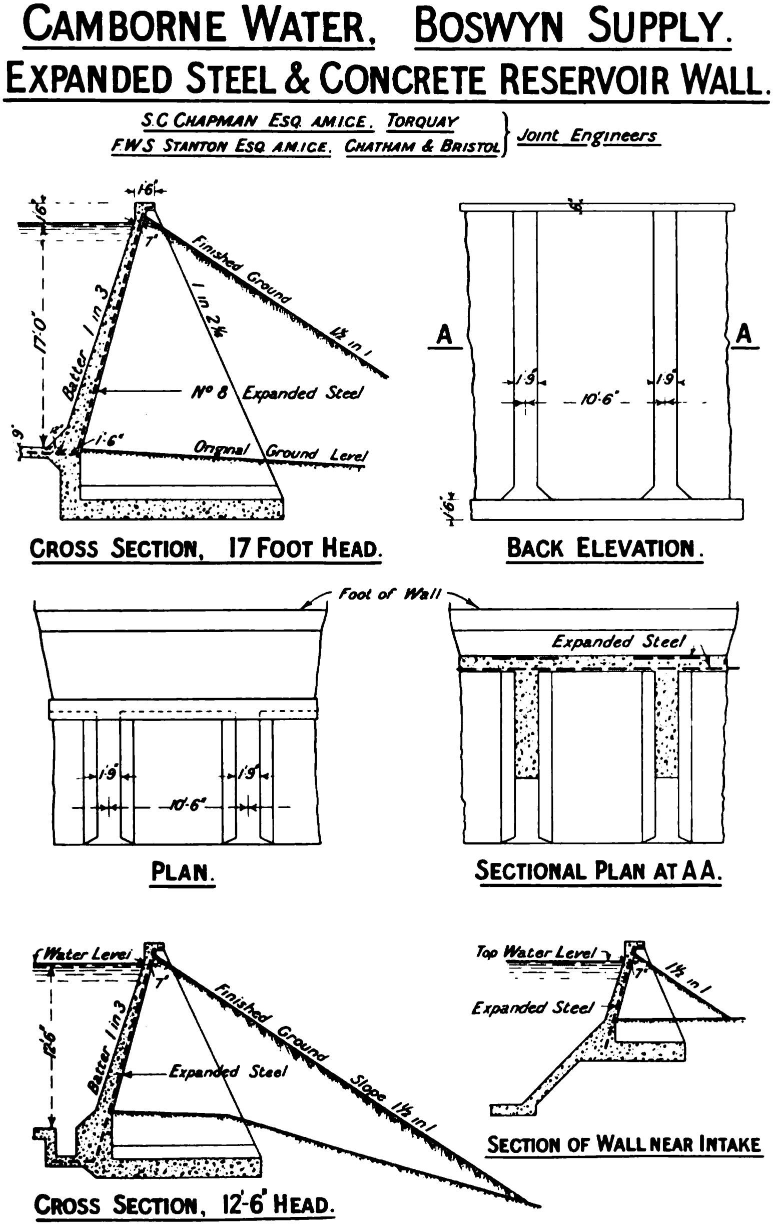


Plan and Sections.

THE NEW CAMBORNE WATERWORKS

matter of unusual difficulty in result of the contours of the site and the interspersion of it by ancient mine workings.

The general lines of construction of both storage (Boswyn) and service (Trevu) reservoirs have been similiar, with the exception that, in the former, the boundaries



Sections showing reinforcement.
THE NEW CAMBORNE WATERWORKS.

of excavations have been lined with concrete 9 in. thick, at slopes of 45 deg., reinforced concrete walls being carried above ground to the top-water level at a face batter of 1 to 3; whilst in the latter, solid walls 15 in. thick have been put in on the same plane with the reinforced walls above ground.

The reinforced walls, varying in thickness from 7 in. at top-water to 1 ft. 6 in. at floor, have been formed on the principle of girder and double cantilever, sheets of expanded steel, No. 8 3-in. mesh, being placed in continuation at $1\frac{1}{2}$ in. from the back face, and at widths of 5 ft. at the same distance from the water-face in front of each counterport. The counterports have been placed at 10-ft. 6-in. centres. These, of a thickness of 1 ft. 6 in. at heads of water not exceeding 10 ft., and 1 ft. 9 in. at heads in excess of 10 ft., have been formed to a back batter of 1 to $2\frac{1}{4}$ founded upon a continuous benching 1 ft. 6 in. thick. The profile, so resolved, works out to dimensions beyond those of a solid dam of concrete of the same specific gravity, for the two reasons that the water pressure per each bay of 10 ft. 6 in. is resisted by 18 in. or 21 in. only of concrete as the case varies, and that the mass per bay in resistance to overturning is greatly reduced.

Concrete Church at Los Angeles.

The aggregate has been granite throughout obtained largely from the excavations, and crushed to the following dimensions, *viz.*, $1\frac{1}{4}$ in., $\frac{3}{4}$ in., and under $\frac{1}{4}$ in. In all work, with the exception of that reinforced, the consistency of concrete has been: four parts of $1\frac{1}{4}$-in. stone, two parts of stone under $\frac{1}{4}$-in. including sand, and one part of cement; and in reinforced work: three and a half parts of $\frac{3}{4}$-in. stone, one and a half parts of stone under $\frac{1}{4}$-in. including sand, and one part of cement.

The floors have been laid in bays, benching 1 ft. wide having been laid down at each joint over the bottom half thickness. Tapered wood fillets were then placed over the centre line of each benching and taken up after the setting of the concrete, and the spaces filled in with 1 to 1 compo, after the contraction of the material.

The surfaces were finished with 1 to 1 compo, $\frac{1}{2}$-in. thick, almost immediately after the concrete had been placed and rammed.

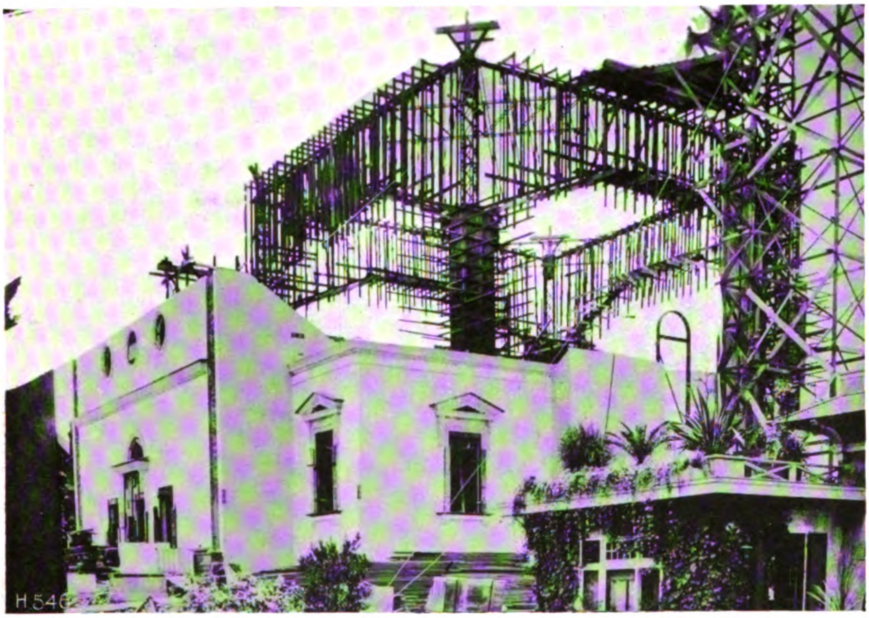
The walls throughout have been rendered $\frac{3}{4}$-in. thick in compo of 4 cement to 1 sand, in two layers of $\frac{3}{8}$-in. thick.

The joint engineers for these works were Mr. S. C. Chapman, M.Inst.C.E., of Torquay, and Mr. F. W. S. Stanton, A.M.Inst.C.E., of Westminster and Chatham, the contracts being executed by Mr. A. Carkeek, of Redruth.

CONCRETE CHURCH AT LOS ANGELES, CALIFORNIA.

OUR illustration on page 522 shows the Second Church of Christian Scientists at Los Angeles, California. This structure occupies a ground area of about 100 ft. by 150 ft. In plan the main auditorium is in the form of a Maltese cross. It has a seating capacity of 1,200, without galleries or obstructions of any sort. Its dimensions are 93 ft. by 106 ft., surmounted by a dome 75 ft. in diameter, the crown of which is 96 ft. above the floor.

Reinforced concrete has been largely employed in the construction of this church, making it substantially fireproof. The dome is a noteworthy feature, and is said to be the largest concrete dome, not only in the United States, but in the world.



View showing reinforcement in place.
CONCRETE CHURCH AT LOS ANGELES.

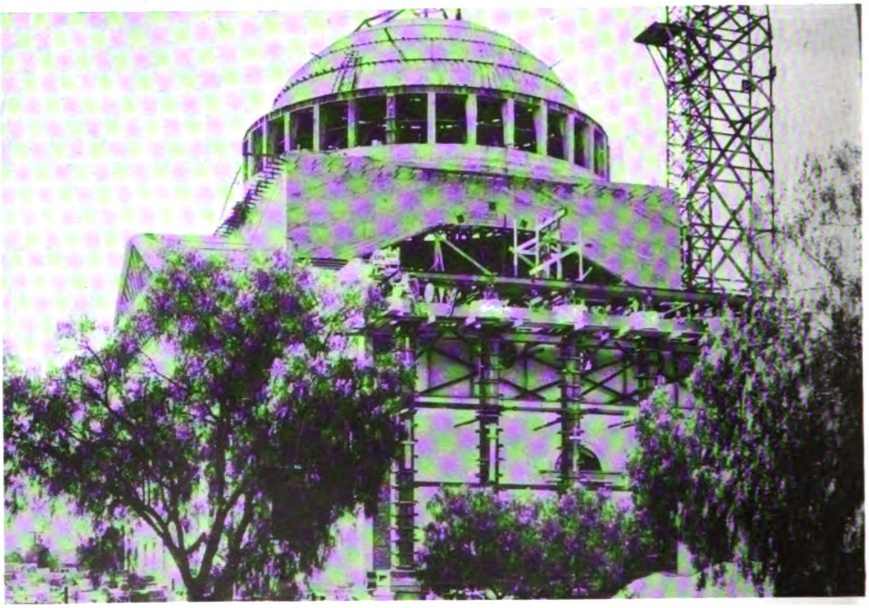
The entrance vestibule extends 38 ft. in length, terminating in a groined arch ceiling that communicates directly with the foyer, which is 32 ft. by 65 ft. To the right and left of the foyer are located the main stairways leading to the auditorium, while twin tunnel stairways leading directly ahead land in the centre of the auditorium. In addition to these two commodious rear stairways are provided, and are reached from the side entrances.

In the rear of the foyer is the Sunday school, with a seating capacity, in cases of emergency, of over 800, and with special arrangements for children's classes. There are also reading-rooms, cloak-rooms, and the secretary's and directors' rooms, and an ample loft to house the great organ. A complete modern and thoroughly-equipped heating and ventilating plant is also installed.

The materials used on the exterior of the church are light gray granite for the underpinning, while the walls are faced with a dull glazed white brick and trimmed with terra cotta of the same colour. The dome and lantern surmounting it are covered with heavy copper, and the pediment roofs with an olive green dull glazed shingle tile.

The building rests on a stratum of gravel. In designing the foundations a bearing power of 3,000 lb. per sq. ft. was assumed and the dead loads only were considered. The foundations are of concrete without reinforcement, with the exception of the footings of the four great piers carrying the dome, which was 18 ft. square and 30 in. thick, reinforced with twisted bars.

The floors, roofs, stairways, etc., are of reinforced concrete, built in the usual manner. The floor over the foyer is carried on beams spaced 12 ft. on centres, having a clear span of 35 ft., but, owing to the pitch of the bowled floor of the auditorium, these beams are but 26 in. deep at one end. The columns carrying the floors are generally 14 in. square, reinforced with four $\frac{3}{4}$-in. twisted bars, wrapped spirally with No. 6 wire, spaced $2\frac{1}{2}$ in. on centres. The maximum load on these columns is 500 lb. per sq. in. on the area enclosed by the reinforcement. The four piers carrying the dome and its supports, consisting of a dead load of 1,400 tons, have each an area of 10 sq. ft. and are reinforced by a steel column made of four 3-in. by $\frac{3}{8}$-in. tees in the outside corner. The four concrete girders connecting these columns have a clear span of 68 ft. and are 20 ft. deep at the supports, 10 ft. deep at the centre, finishing 16 in. thick. These girders are reinforced by hollow steel trusses and twisted bars.

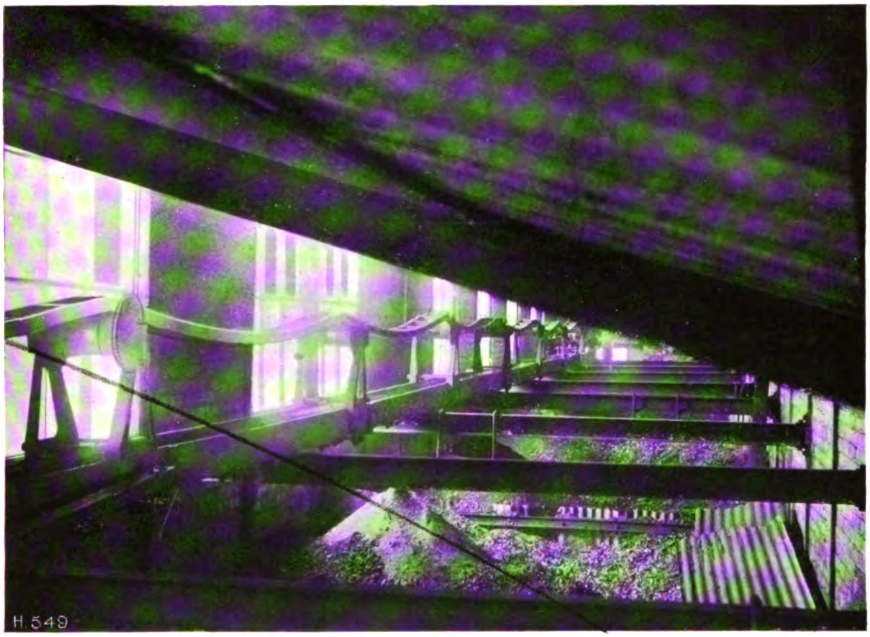


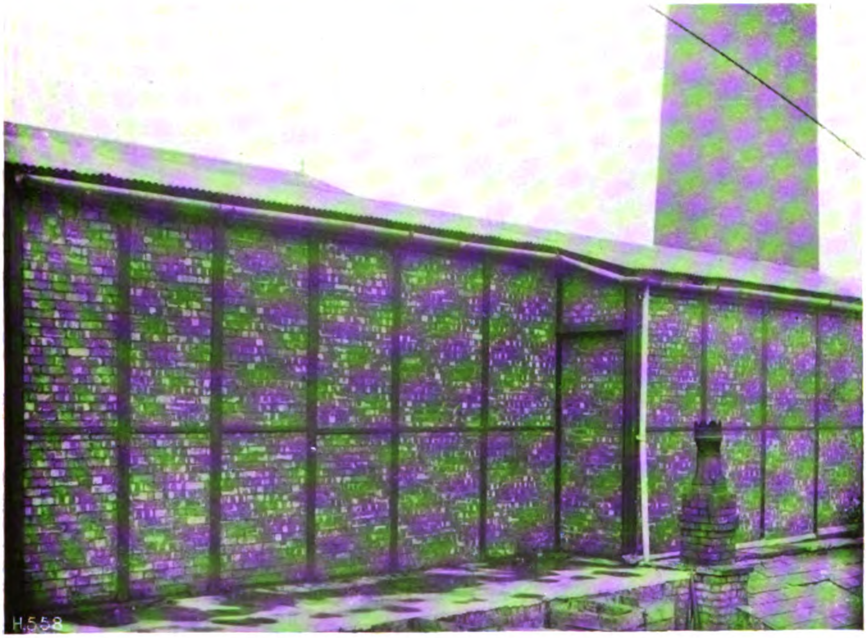
Forms for dome in position.
CONCRETE CHURCH AT LOS ANGELES.

In constructing this work the steel columns were assembled in their full length and hoisted to their final positions. Short cross arms were secured to the tops and the steel trusses hoisted by block and tackle, and hung from these arms. After the four trusses were secured in their correct positions, four hollow latticed girders 30 ft. long and 5 ft. deep were bolted to them across the corners, at an angle of 45 deg. The centres of the trusses and the girders are points of support for the dome. Eight additional points of support are located at the centres of eight intermediate concrete beams on lines tangent to the dome, and are supported at their ends by the trusses and girders.

The concrete for the piers, girders, dome and roofs was hoisted in a concrete bucket to a point about 30 ft. above its final resting-place and then dumped into a 7-in. sheet-iron pipe, which conducted it to the forms. This pipe had a swivel joint at the centre of the building, which facilitated the delivery of the concrete uniformly in the forms on all sides of the building. Three bolts, $\frac{3}{4}$ in., were embedded in the concrete

Interior view of coal bunkers.





Exterior view, showing vertical girders and reinforced brickwork.

COAL BUNKERS AT STOCKPORT.

of the trusses and girders directly below the centres of each of the columns of the dome, and 4-in. by 4-in. blocks were afterwards secured by these bolts, and formed the supports for the outer ends of thirty-two radial trusses which supported the forms for the dome. The other ends of the trusses were carried on a 16-ft. sq. wooden tower erected on the floor of the auditorium. The rough boarding of the form of the dome was made up in sections and hoisted into position. The first section of the dome consists of a 3-ft. ring 16 in. thick, bearing on the beams, girders, and trusses and reinforced at the bottom with two 1-in. bars, and on the outer face with six 1-in. bars. The next section of the dome, as constructed, consisted of the thirty-two columns and a horizontal circular ring connecting the tops of these columns. The columns have a minimum section of 12 in. by 14 in., and are reinforced with four ¾-in. twisted bars wrapped spirally with No. 6 wire, spaced 2½ in. on centres, the ends of the bars projecting 6 in. or 8 in. into the lower and upper rings.

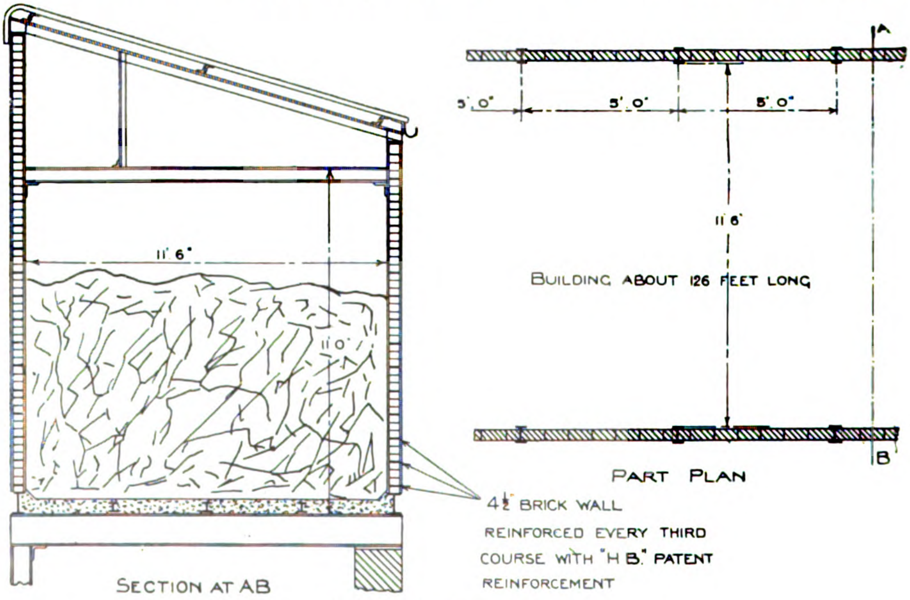
Mr. A. C. Martin was employed by the architect in the capacity of structural engineer, who had direct charge of all structural features and supervised their erection. The C. J. Kubach Company were the contractors.

COAL BUNKERS AT STOCKPORT.

THE coal bunkers illustrated have been recently erected by the Stockport Electricity Works at their Generating Station at Stockport.

As will be seen from the plan, the general construction was that of a steel frame building filled in with reinforced brickwork.

Messrs. Richard Johnson, Clapham and Morris' patent "H.B." reinforcement for brickwork was used, reducing the thickness of the walls from 9 in. to 4½ in., although there was considerable lateral pressure exerted by the coal being piled inside to the height of about 12 ft.; 4½-in. in each wall was thus saved, which considerably reduced the cost.



Plan and Section of Bunkers.

The building is about 126 ft. long, reinforced every third course with "H.B." patent reinforcement.

The engineer for this work was Mr. R. Lomax, Borough Electrical Engineer, Stockport, and the bulk of the work was carried out by the Electricity Department.

NEW USES FOR CONCRETE

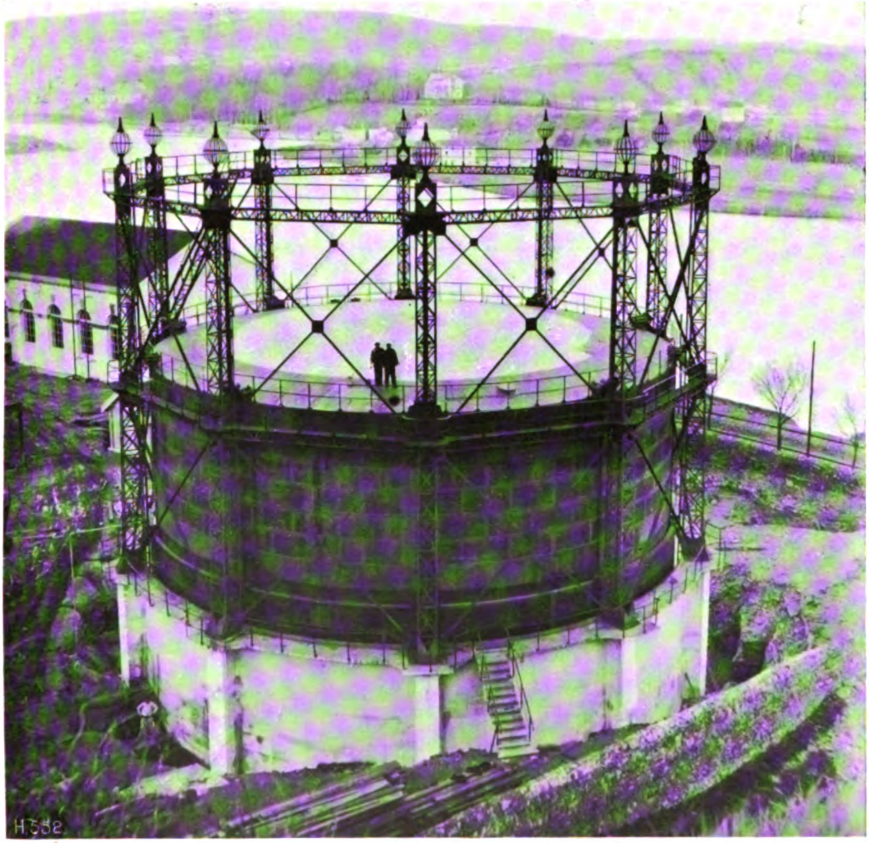
AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE GASHOLDER-TANK AT SAN SEBASTIAN.

REINFORCED concrete seems to be making greater strides in the northern portions of Spain than in any other part of that country, and the number of different applications of this material there is increasing day by day. Houses, bridges, reservoirs, etc., have been constructed of reinforced concrete, and in the present case we are showing a gasholder-tank built at San Sebastian for the Municipal Gas Company, under the supervision of M. Wenceslas Aguirrebengoa, which is the first tank built of the new material in Spain.

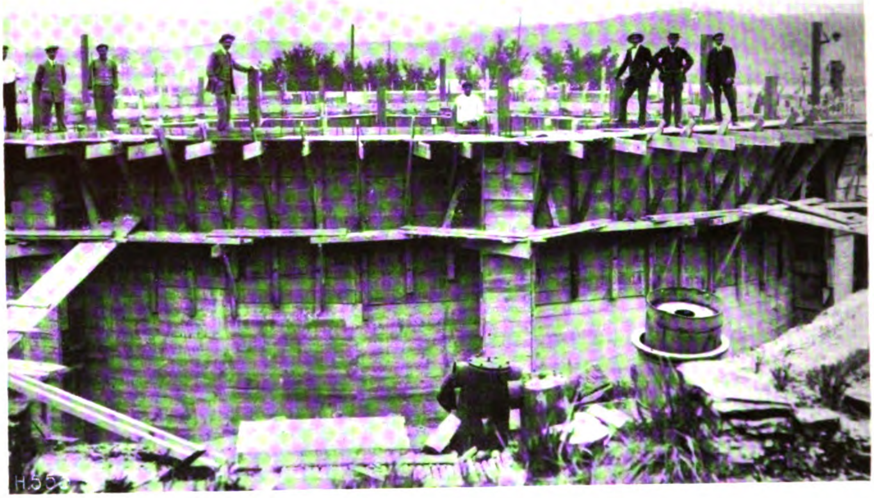
Owing to the great increase in the consumption of gas, it was necessary to

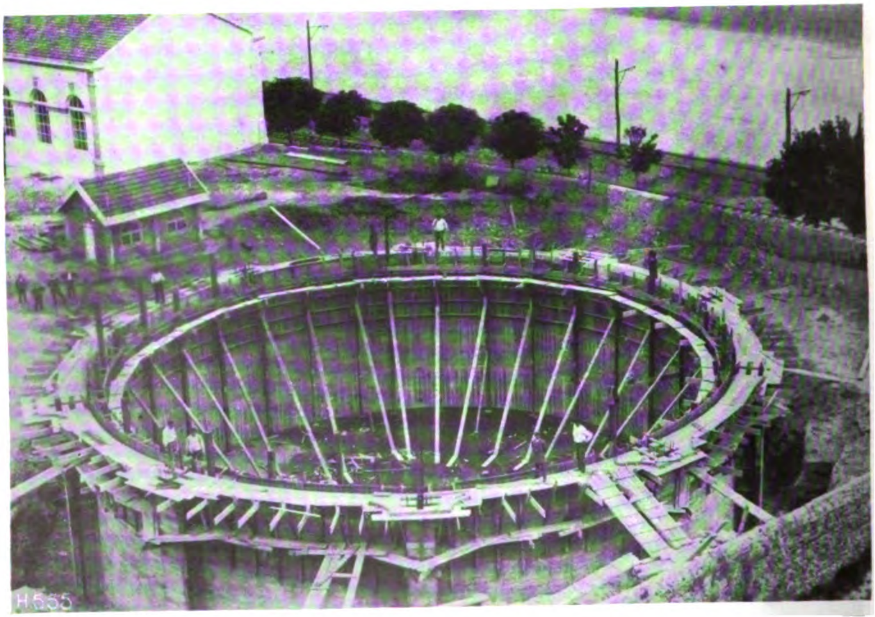


REINFORCED CONCRETE GASHOLDER-TANK, SAN SEBASTIAN.

augment the number of gasholder-tanks, and the company decided to have a new one of 6,000 cub. metres capacity, to be built on the Hennebique system.

The tank is 24 metres (78 ft. 9 in.) in diameter and 7·80 metres (25 ft. 8 in.) high.

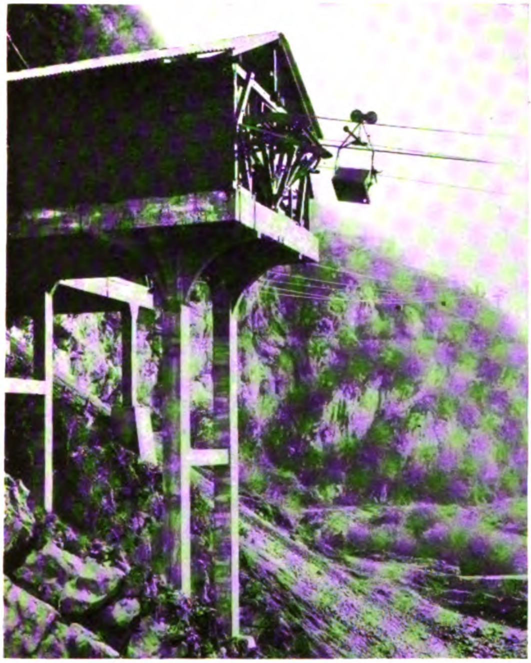


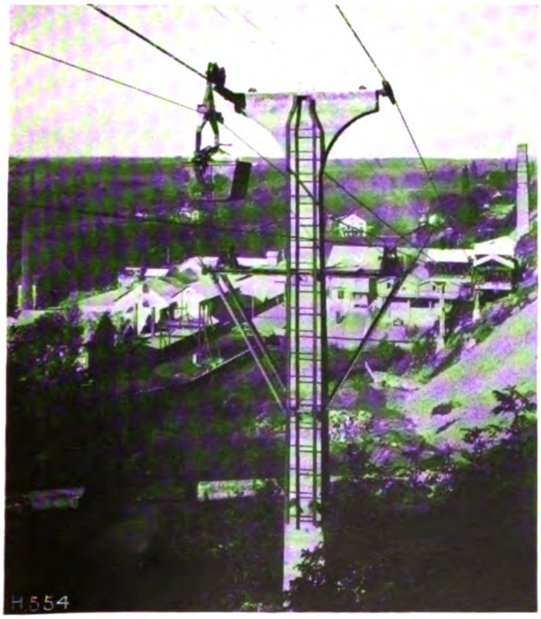


Views showing Gasholder-Tank in Course of Construction.

The cylindrical vertical wall is divided into ten sections by the same number of **T**-shaped buttresses to support the iron stanchions of the tank. The width of the circular bars of iron is 2 ft. 8 in., and they are 8 in. thick.

In designing this tank the calculations were made in the same way as for a circular reservoir, under the assumption that it was divided into zones 0·50 metres (1 ft. 8 in.) high, the buttresses only being made to receive the metal stanchions.





The work was carried out in two and a half months. The concrete was well rammed to prevent porosity and to lessen the danger of filtration.

When the centering was removed and the interior and exterior of the tank rendered with Portland cement and gravel in the proportion 1 to 2, a test was undertaken for resistance and impermeability, by filling the tank with water. It took eight days to do this owing to the scarcity of water and the great capacity of the tank. The test proved most successful, and during the time it lasted no cracks or displacement whatever were noticed.

The general appearance of the tank is very pleasing, especially if compared with those made of stone and masonry, and it is also more economical and can be built in a much shorter space of time.

We are indebted to our contemporary *Le Béton Armé* for our illustrations.

SUPPORTS FOR AERIAL TRANSPORTERS.

Poles to support telegraph or other wires are subject to decomposition if made of wood and to oxidisation if made of iron, and the latter method of construction is also very expensive. With reinforced concrete, the factor of safety for accidental shocks is greater, the cost of erection less, and there are no maintenance charges.

The Société des Usines de Granchamp et de Roche has adopted reinforced concrete posts and supports (on the Hennebique system) for the wires which are used to carry sand, etc., to their works, and they have proved very strong and also very economical. One of our illustrations shows the starting station with the bucket hung on the wires, and the other is a view of the support for the wires midway between the two stations.

Le Béton Armé also kindly placed these illustrations at our disposal.

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

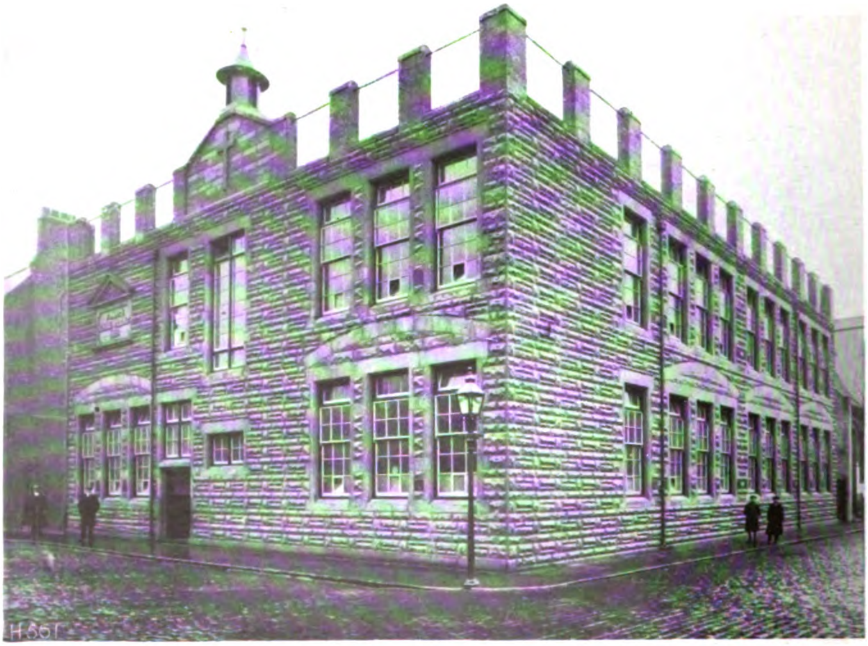
CONCRETE STONE BUILDING BLOCKS.

THE Dring Patent Building Block Machine, for which the Stockton Stone & Concrete Co., Ltd., of Norton, near Stockton-on-Tees, are the sole manufacturers, is simple and strong in construction, portable and adaptable, and any design of face plate such as rockface, sparrow-pecked, tooled, etc., etc., can immediately be fixed without in any way dislocating the machine.

Only one action is required to open or close the "Dring" machine, as merely by lowering the lever it is closed, the cores placed in position, and the machine ready to receive the concrete, and again by raising the lever the machine opens, cores are withdrawn, and the stone is ready for easy removal.

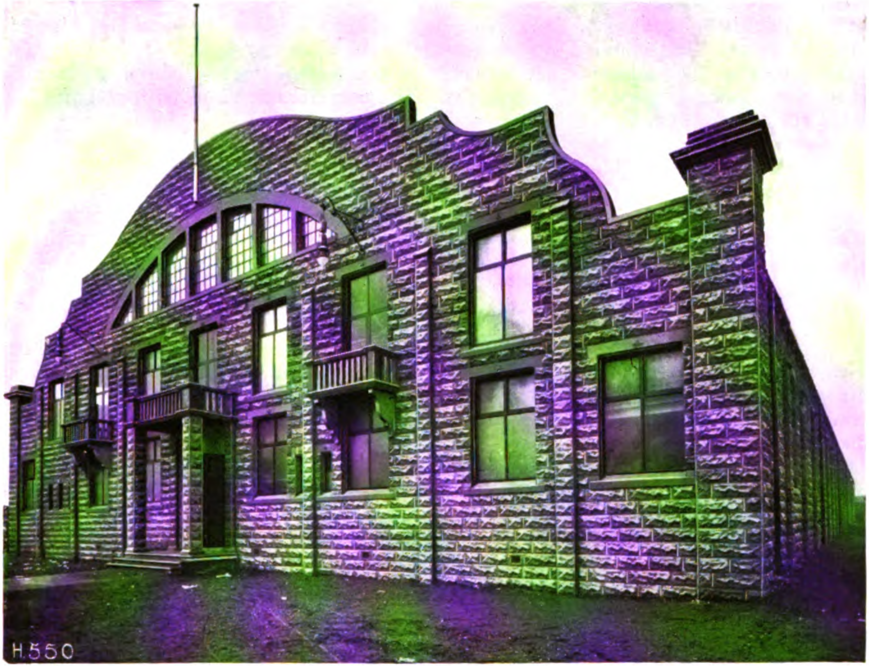
It will make any length of block up to 2 ft. 8 in., and width up to 12 in., and any height up to 10 in. It can also be adapted to make label, cornice, angle quoins, chimney blocks, etc., by using the detachable plates.

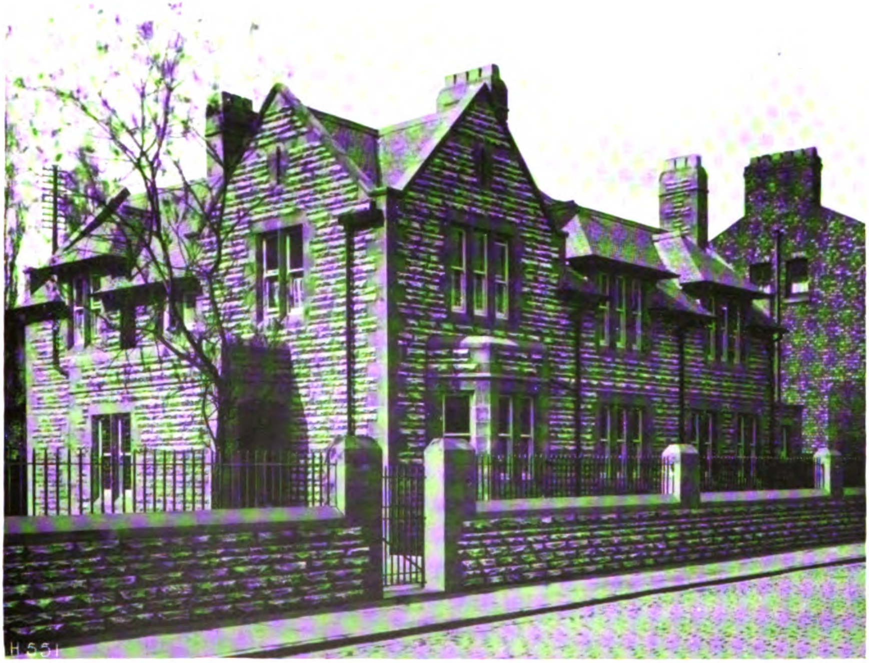
A number of large buildings have been erected in the Northern counties with building blocks manufactured with the "Dring" machine, and we are showing examples of three different kinds of buildings in which they have been used.



ST. MARY'S SCHOOL, STOCKTON-ON-TEES.

QUEEN'S SKATING RINK, WEST HARTLEPOOL.





THE PRESBYTERY, STOCKTON-ON-TEES.

The illustration on page 528 is of St. Mary's School, Stockton-on-Tees, built of concrete blocks which have a special stone finish.

The school is 85 ft. long by 62 ft. wide and 33 ft. in height. It is two stories high and the floors are built of reinforced concrete on the Kahn system.

The whole of the staircases are fireproof and the steps are non-slipping, manufactured by the Stockton Stone & Concrete Co. The corridors are laid with red and black concrete tiles also made by this Company.

A novel feature of the building is the playground on the roof, which was erected with 9-in. concrete facing blocks and a lining of glazed brickwork.

On page 529 we show an illustration of a Presbytery at Spring Street, Stockton-on-Tees, made of concrete blocks. There is also a view of the Queen's Skating Rink at West Hartlepool, which is 270 ft. in length by 106 ft. wide, constructed entirely of hollow concrete blocks, rockfaced outside and sparrow-pecked inside.

SIEGWART REINFORCED CONCRETE POLES AND PIPES.

THE application of concrete and steel in poles and pipes as advocated by Messrs. Siegwart, Ltd., of Caxton House, Westminster, must be of interest to all engineers.

The process has already been described in our journal, but in addition it is well to remember that these poles can now be made with advantage to meet all reasonable requirements.

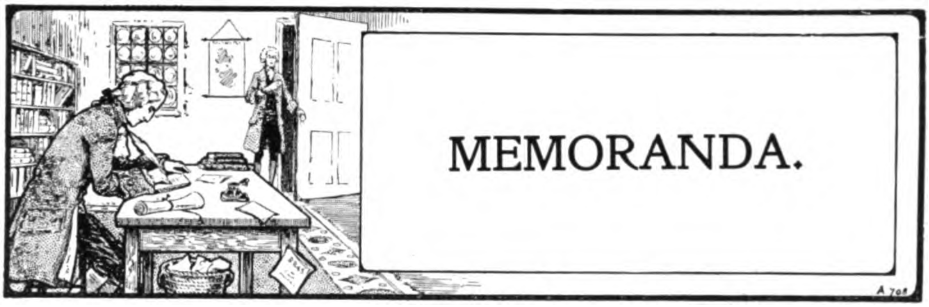
In the Albula Valley, Switzerland, as many as 2,000 poles have been erected for the purpose of power transmission, each pole carrying six wires. They have been erected for two years and are most satisfactory. The poles vary in height from 34 to 42 ft. above ground, no more than 5 ft. of the pole being in the ground.

We understand that Messrs. Siegwart, Ltd., are also making tramway poles which will meet with the requirements of the Board of Trade as to tests, which favourably contrast with tests of iron poles, but being of a larger diameter at the base do not require to be so far in the ground, as they present a better bearing surface.

A number of poles have been erected in Cheshire, carrying twelve wires $\frac{3}{8}$-in. in diameter, which are stretched quite taut, under which strain the poles are stated to be entirely satisfactory.

Messrs. Siegwart have been making a series of tests of reinforced concrete pipes lined with asphalt. These extensive tests have been carried out under the direction of the eminent engineer, Professor Hilgard. We are informed that when under pressure these pipes only burst at 630 and 750 lbs. per sq. in., and up to the moment of bursting they were perfectly watertight. A joint broke at 630 lbs.

The cost of manufacture of pipes on this system is stated to be very much less than that of cast iron, and there are practically no maintenance charges, as these poles require no painting. The larger the diameter of the pipe the greater the saving in cost of manufacture. They are now made in lengths of 16 ft. 6 in., which up to the present is the maximum.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Standard Specification for Reinforcing Bars for Concrete.—The Association of American Steel Manufacturers has recently adopted by letter ballot a standard specification for reinforcing rods for concrete, as follows :

1. *Manufacture.*—Steel may be made by either the open hearth or Bessemer process. Bars shall be rolled from billets.

2. *Chemical and Physical Properties.*—The chemical and physical properties shall conform to the following limits :

Properties considered.	Structural Steel Grade.		High Grade.		Cold Twisted Bars.
	Plain Bars.	Deformed Bars.	Plain Bars.	Deformed Bars.	
Phosphorus, maximum :					
Bessemer	·10	·10	·10	·10	·10
Open hearth	·06	·06	·06	·06	·06
Ultimate tensile strength, lbs. per sq. in.	55/70,000	55/70,000	80,000 min.	80,000 min.	R'c'd'd only
Yield point, minimum, lbs. per sq. in.	33,000	33,000	50,000	50,000	55,000
Elongation, per cent. in 8 in., minimum	$\frac{1,400,000}{\text{T. S.}}$	$\frac{1,250,000}{\text{T. S.}}$	$\frac{1,200,000}{\text{T. S.}}$	$\frac{1,000,000}{\text{T. S.}}$	5%
Cold bend without fracture :					
Bars under ¾ in. in diameter or thickness	180°d = 1t.	180°d = 1t.	180°d = 3t.	180°d = 4t.	180°d = 2t.
Bars ¾ in. in diameter or thickness and over ...	180°d = 1t.	180°d = 2t.	90°d = 3t	90°d = 4t.	180°d = 3t.

The hard grade will be used only when specified.

3. *Chemical Determinations.*—In order to determine if the material conforms to the chemical limitations prescribed in paragraph 2 herein, analysis shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt or blow of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector.

4. *Yield Point.*—For the purposes of these specifications, the yield point shall be determined by careful observation of the drop of the beam of the testing machine, or by other equally accurate method.

5. *Form of Specimens.*—(*a*) Tensile and bending test specimens may be cut from the bars as rolled, but tensile and bending test specimens of deformed bars may be planed or turned for a length of at least 9 in. if deemed necessary by the manufacturer in order to obtain uniform cross section.

(*b*) Tensile and bending test specimens of cold-twisted bars shall be cut from the bars after twisting, and shall be tested in full size without further treatment, unless otherwise specified as in (*c*), in which case the conditions therein stipulated shall govern.

(*c*) If it is desired that the testing and acceptance for cold-twisted bars be made upon the hot rolled bars before being twisted, the hot rolled bars shall meet the requirements of the structural steel grades for plain bars shown in this specification.

6. *Number of Tests.*—At least one tensile and one bending test shall be made from each melt of open hearth steel rolled, and from each blow or lot of 10 tons of Bessemer steel rolled. In case bars differing $\frac{3}{8}$-in. and more in diameter or thickness are rolled from one melt or blow, a test shall be made from the thickest and thinnest material rolled. Should either of these test specimens develop flaws or should the tensile test specimen break outside of the middle-third of its gauged length, it may be discarded and another test specimen substituted therefor. In case a tensile test specimen does not meet the specifications an additional test may be made.

(*d*) The bending test may be made by pressure or by light blows.

7. *Modifications in Elongation for Thin and Thick Material.*—For bars less than $\frac{7}{16}$-in. and more than $\frac{3}{4}$-in. nominal diameter or thickness, the following modifications shall be made in the requirements for elongations:

(*e*) For each increase of $\frac{1}{4}$-in. in diameter or thickness above $\frac{3}{4}$ in. a deduction of 1 shall be made from the specified percentage of elongation.

(*f*) For each decrease of $\frac{1}{16}$-in. in diameter or thickness below $\frac{7}{16}$-in. a deduction of 1 shall be made from the specified percentage of elongation.

(*g*) The above modifications in elongation shall not apply to cold twisted bars.

8. *Number of Twists.*—Cold-twisted bars shall be twisted cold with one complete twist in a length equal to not more than twelve times the thickness of the bar.

9. *Finish.*—Material must be free from injurious seams, flaws or cracks, and have a workmanlike finish.

10. *Variation in Weight.*—Bars for reinforcement are subject to rejection if the actual weight of any lot varies more than 5 per cent. over or under the theoretical weight of that lot.

Action of Sewage on Concrete.—We notice the following letter in a recent issue of *Engineering Record*, commenting on the paper read by Mr. Chambers before the Concrete Institute:

"In connection with the action of sewage on concrete and the reported example of this action at Hampton, England, as described by Mr. Sidney H. Chambers, and abstracted in the *Engineering Record* of May 14th, 1910, I have recently had occasion to observe concrete which had been subjected to contact with sewage for seven years without showing the slightest deterioration. The structure to which I refer is a concrete culvert 157 ft. long, 13 ft. 6 in. high and of 20 ft. clear span, which serves to carry sewage from the Canal Street sewer in St. Paul, Minn., through the freight yards just outside the St. Paul Union Depôt. The sewage is emptied into the Mississippi River.

"The culvert was built during the summer of 1902 by the Chicago, Milwaukee and St. Paul Railway under the direction of Mr. C. F. Loweth. The side walls, which vary in thickness from 6 ft. at their base to 4 ft at their top, are constructed of 1 : 2 : 5 unreinforced concrete. The sewage flowing through the structure varies in depth from a few inches to 4 ft. or 5 ft., and consists of domestic waste, with some manufacturing sewage, and a proportion of street drainage that becomes excessive during rainy seasons. That its strength is as great as that of the sewage in the average American cities is apparent from the stench which is said to periodically arise from the culvert. The current through the structure is too rapid to allow putrefaction to progress to any great extent, but some sedimentation takes place, with a consequent formation of decomposition products.

"In the fall of 1909, seven years after the culvert was completed, an examination was made in order to note any deterioration. The side walls were found to be thoroughly sound and free from any sign of attack by the sewage. The sole effect observable was a collection of scum along the areas in the neighbourhood of the surface of the sewage, and brown stains for a foot or two above these areas. These latter stains were apparently produced by iron oxide. The cover and the upper areas of the side walls, which had always remained out of contact with the sewage, were entirely free from any signs of attack by the latter agent.—FRED. G. HEUCHLING."

Reinforced Macadam Pavement.—A reinforced macadam pavement under trial near Paris, the idea of M. Guiet, has a foundation of concrete 2 in. thick, and on this, along its length, are laid steel strips 2 ft. apart, with steel wires at a distance of 8 in. on each side, and smaller cross-wires at intervals of 8 in., cement mortar containing broken stone being spread thickly on this reinforcement. The steel strips are 1¼ in. wide and $\frac{5}{16}$-in. thick, set on edge; the main wires are about ⅛-in. in diameter. The road, resembling in appearance an irregular stone paving with cement joints, costs about 5s. per sq. yd., but it is expected that its durability and small repairs will make it as economical as ordinary macadam.

Tensile Test.—Recently, Prof. A. N. Talbot, following a discussion in America, in which importance had been laid only on compressive tests on concrete, stated that sufficient importance had not been given to the tensile test. The failure of concrete in compression may, he urged, be, in cases, due to lack of tensile strength, allowing the concrete to split off laterally, as is more or less characteristic in compression failures. Moreover, the tensile strength is important in bond between steel and concrete, while shearing and diagonal tension failures are more likely to occur with concrete of low tensile strength.

Placing Concrete Aqueduct Lining in Freezing Weather.—Owing to delays in building the foundations and piers of some of the aqueduct bridges on the Illinois and Mississippi Canal it was necessary to place some of the concrete lining in cold weather. It was important, therefore, that precautions be taken to keep the concrete from freezing. The methods employed were described by Mr. H. E. Reeves, U.S. junior engineer, in a paper before the last convention of the Illinois Society of Engineers and Surveyors.

The last concrete was deposited December 28th, and the temperature during the final weeks dropped as low as 12° or 15° above zero, barely rising to the thawing point in the middle of the day. Owing to the thinness of the lining, 6 in. on the bottom of the trough and 9 in. on the sides, and its exposed position, considerable care was necessary. To heat the concrete materials, the exhaust steam from the mixer engine was turned into the drum of the mixer. This was accomplished by conducting the exhaust pipe to a point in front of the discharging opening of the drum, so that the drum when tilted for discharging would just clear the end of the pipe. The force of the exhaust then carried the steam into the revolving drum, where complete mixture with the dropping particles of concrete utilised practically all of the heat remaining in the steam. Though the expense was absolutely nothing, the results were really surprising. The temperature of the deposited concrete averaged probably 70°, while if a batch were left in the mixer 3 minutes or more its temperature would be 90° to 100°.

To protect the deposited concrete, the inside of each 35-ft. span at the close of the day's work was roofed over with inch boards laid loosely on horses, the ends being closed with pieces of canvas, and into the room thus formed live steam from the boiler was conducted through a hastily laid pipe line. The night watchman kept up the steam, the amount needed being very small. Steam was kept on the concrete for two nights or for about 40 hours after being laid. It was considered that the outside was sufficiently protected by the 2 in. forming. On the third day the forms if needed were removed and the concrete left exposed. The cost of this protection was about 12 to 15 cents per cubic yard of concrete, and the results, Mr. Reeves states, were perfect. As an illustration of the need of protection, it may be noted that the feed pipe for the boiler froze one night about midnight and steam was shut off from the concrete for about 7 hours. The concrete froze to some extent, and about ½ in. of the surface afterwards shelled off.

Concrete for Roads.—An all-mixed concrete road 18ft. wide and 1 mile long has been built in Wayne County, Mich., and has given such satisfaction that 8 or 10 miles more are contemplated, according to Mr. G. A. Burley, who described the work recently in "Good Roads." After trying other methods expansion joints were put in at 100 ft. intervals, a strip of heavy 4-ply tar paper being introduced between abutting sections.

The maximum expansion for such a section, Mr. Burley states, will not exceed ⅛ in., and after a season's traffic the expansion joints were not seriously affected by spalling. On next year's work it is the intention to omit open joints entirely and lay the concrete in 25 ft. sections with tar paper between each pair. A 1 : 2 : 4 mixture is used by Mr. Burley, and according to him the all-mixed concrete road has shown superiority over macadam from the standpoint of maintenance, and in some cases was cheaper in initial cost. On the mile stretch referred to the contract price for grading placing concrete was a little less than one dollar per sq. yd.—*Engineering Record.*

Tenders Invited for Reinforced Concrete Vaults and Retaining Walls.—The Commissioners of H.M. Works and Public Buildings are prepared to receive Constructional Schemes and Tenders based thereon for the Erection in Reinforced Concrete of Vaults and Retaining Wall for the Public Offices Extension, Westminster, S.W.

Any system or systems of construction may be adopted for the whole or part of the work, and full details must be furnished immediately for examination if necessary.

Drawings, specification, and a copy of the conditions and form of Contract may be seen on application at this Office, and copies of the plans, specification, and form of Tender may be obtained upon payment of two guineas, which sum will be returned to those persons sending in Tenders in conformity with the conditions.

Contractors Tendering will have to satisfy the Commissioners as to their capacity to erect reinforced structures.

The Commissioners do not bind themselves to accept the lowest or any Tender.

Tenders must be delivered before Eleven a.m. on the 14th July, 1910, addressed to the Secretary, H.M. Office of Works, Storey's Gate, London, S.W., and endorsed: "Tender for Reinforced Construction, Westminster."

H.M. Office of Works,
22nd June, 1910.

Reinforced Concrete in School Building.—At a recent meeting of the London County Council at the County Hall, Spring Gardens, the General Purposes Committee reported that during the Whitsun recess the Chairman of the Education Committee asked them to authorise, as a matter of urgency, the giving of effect to a recommendation of the Education (Buildings) Sub-Committee, which time did not admit of submitting to the Education Committee, that the architect should give evidence on the building law in London in relation to reinforced concrete and steel skeleton construction before a departmental committee appointed by the Board of Education to consider the cost of the buildings of public elementary schools. They authorised, through their chairman, the giving of such evidence on the distinct understanding that the Council was in no way bound by any opinions that might be expressed in such evidence, or committed as to its future policy in the matter.

Test on Hy-Rib.—An interesting test on Hy-Rib, a new product of the Trussed Concrete Steel Co., Ltd., Caxton House, Westminster, was carried out on April 14th last at the new extension works, British Museum, by the contractor, Mr. W. E. Blake, of Montague Place, W.C., and Plymouth.

Hy-Rib is a metal lathing of great rigidity, which is attained by doubling the sheet in a ridge every three inches along its length, the space between being expanded. This obviates the need of studs or other supports in the vertical, and will span up to 5 ft. on the flat as a reinforcement to floor panels or roofs, the mesh being of a nature capable of containing the liquid concrete without the aid of the usual centering. It was to ascertain the degree to which this was successful that the two slabs were cast six weeks earlier, and the intention of the test was to load them to destruction.

Regarding the ability of the Hy-Rib to retain the liquid, the result was highly satisfactory. Each slab was 4 ft. 6 in. by 4 ft. 3 in. clear span. No. 1 was cast 3½in. thick with furnace clinker, of which a very trifling amount percolated and fell on the paper spread below to receive it. No. 2 was ballast concrete of the same thickness, and practically nothing fell. The mixture in each case was one part of Portland cement, two parts of sand, and three parts of aggregate. Hy-Rib of No. 24 gauge of a sectional area of ·335 sq. in. per foot of width was used in each case.

The load was applied by means of blue bricks stacked so as to prevent arching. Slab No. 1 was loaded first, and the deflection noted at various stages was as follows:—

Load per sq. foot.	Deflection.
266 lb.	$\frac{1}{32}$ in.
324 „	$\frac{1}{16}$ „
440 „	$\frac{3}{32}$ „
673 „	$\frac{1}{8}$ „
1080 „	$\frac{5}{32}$ „

Slab No. 2 was only loaded to the extent of 673 lb. per sq. ft., the deflection being $\frac{1}{16}$ in., and as the available headroom was nearly reached by the load of 1,080 lb. per ft. super on Slab No. 1 it became evident that the original intention to break even the furnace clinker slab was out of the question.

The test, which was in all respects highly satisfactory, was witnessed by Messrs. W. Noble Twelvetrees, W. A. Thain, of Cardiff, W. C. Sharman, of Leicester, E. S. Blake, and Mr. Moritz Kahn, of the Trussed Concrete Steel Co., Ltd.

The Society of Engineers.—The third visit of the present session took place on June 15, when, by the courtesy of Mr. Maurice Fitzmaurice, C.M.G., M.Inst.C.E., a party of members of the Society and their friends visited the site of the new County Hall of the London County Council on the south side of the Thames at Lambeth. The site for the building occupies an area of over 5 acres, of which about 1½ acre is reclaimed from the River Thames, and is bounded on the east side by Belvedere Road, and on the south by Westminster Bridge Approach. The river is excluded by an embankment wall similar to the Victoria Embankment on the opposite side of the river. The embankment wall is founded on the London clay formation at a depth of about 20 ft. below Ordnance datum, and the whole area behind the wall is to be covered with a raft of concrete 5 ft. thick, resting on the Thames ballast at a level of 8 ft. below the same datum. On this raft the building will be erected. The embankment wall is being built behind a cofferdam consisting of a single row of Oregon pine piles, 14 in. sq., grooved and tongued, which are driven about 12 ft. into the clay. The wall is of 6 to 1 Portland cement concrete, faced with Cornish and Aberdeen granite above low-water level. In front of the central portion of the future building the wall has two flights of steps leading down to the river, and the granite is finished with a rough face. Behind the wall is a series of arches, forming storage vaults, and on the top of them will be a terrace, access to which will be by a flight of steps from Westminster Bridge. Special precautions were taken in constructing the foundations of the new wall near the abutment of Westminster Bridge. The bridge is founded on cast-iron piles, and, in order to avoid any possibility of weakening this support, a length of 30 ft. of the wall next the bridge was founded in a caisson, which was sunk with compressed air. The foundation of the abutment was also partly surrounded with steel sheet piling driven down to the London clay. The embankment wall has been designed and is being constructed under the supervision of Mr. Maurice Fitzmaurice, C.M.G., the chief engineer to the London County Council, the contractors being Messrs. Price and Reeves. The raft foundation is being laid by Messrs. F. and H. F. Higgs, under the supervision of Mr. W. E. Riley, F.R.I.B.A., the Council's superintending architect, who is also associated with the architect for the whole scheme, Mr. Ralph Knott, F.R.I.B.A.—*Engineering.*

A Moist Closet for Cement Tests. — A moist closet, designed expressly for maintaining a constant temperature and a constant degree of moisture for setting tests of cement, has been in use by the Department of Railways and Canals, Canada, on the Lachine Canal, where especial importance is attached to time of setting, because the cement is used under water. With other types used the temperature and moisture are apt to be materially changed in opening the closet to make tests. The new closet, therefore, was provided with an armhole, through which the test is made, the door being used only for placing the pats. The cuff of the coat prevents any air entering, and on the arm being withdrawn the hole is quickly closed. The closet is 3 ft. high, 3 ft. wide, and 18 in. deep, with walls of concrete 2 in. thick. The bottom of the closet acts as a tank to hold about 2 in. of water. The mixture was rich, and there is no leakage. The temperature inside the closet is usually 65 deg. in summer and winter, varying 1 deg. Wet cement bags are placed on top during very hot weather, and repeated tests have indicated, it is stated, that the temperature can be evenly regulated. Water is seldom added to the pan forming the bottom of the closet, showing that little or no evaporation takes place inside the closet. The closet is

USED AT H.M. DOCKYARD ROSYTH WALMER ACCRA WATER-WORKS HEATON PARK RESERVOIR SOUTHERN NIGERIA RLY DEPTFORD CREEK BRIDGE &c &c. &c.

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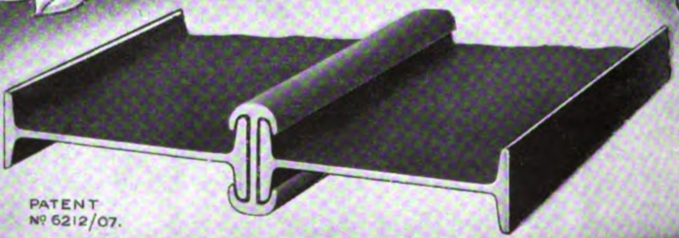
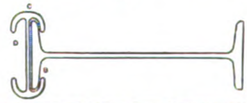
USED BY THE ADMIRALTY CROWN AGENTS FOR THE COLONIES QUEENSLAND AND WESTERN AUSTRALIAN GOVERNMENTS & LEADING CONTRACTORS &c. &c.

1. Each pile consists of an Interlocking member and Joist, which are driven together.
2. The Interlocking member is always driven over the flange of last Joist driven, so that it does not fill with soil.
3. Drives freely and pulls freely.
4. Practically watertight without caulking.
5. Can be driven at one-fourth the cost of timber.
6. Can be used repeatedly.





Size of Joist.	Weight per square foot when interlocked.	Weight of Joist per foot run.	Weight of Clutch per foot run.	A	B	C	D
15 in. × 5 in.	43 lbs.	39·5 lbs.	15·5 lbs.	·4 in.	·69 in.	·5 in.	·25 in.
12 in. × 5 in.	52·8 lbs.	39 lbs.	15·5 lbs.	·44 in.	·664 in.	·5 in.	·25 in.
10 in. × 5 in.	58·4 lbs.	35 lbs.	15·5 lbs.	·42 in.	·625 in.	·5 in.	·25 in.
8 in. × 5 in.	62·09 lbs.	28 lbs.	15·5 lbs.	·35 in.	·575 in.	·5 in.	·25 in.
6 in. × 5 in.	76·2 lbs.	25 lbs.	15·5 lbs.	·41 in.	·52 in.	·5 in.	·25 in.
5 in. × 5 in.	88·18 lbs.	24 lbs.	15·5 lbs.	·37 in.	·551 in.	·5 in.	·25 in.

Stocked in all lengths up to 60 feet. Longer lengths are joined with Fishplates. Special Corners. Junction. Wedge and Curved Piles. Lighter sections to order.

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THE BRITISH
STEEL PILING CO.
DOCK HOUSE, BILLITER ST,
LONDON. E. C.

carried on a base about 30 in. high, and two open shelves are built below it.—*Engineering Record.*

Concrete* v. *Stoneware Pipe Sewers.—A municipal officer from one of the cities in far-off British Columbia writes me to ascertain for his Corporation what is the general opinion amongst English engineers regarding the reliability, etc., of concrete sewer pipes, and whether they are as good as vitrified pipes. It may interest him to know that concrete sewer pipes have been made in this country for the last twenty-five years, and their popularity with engineers for diameters exceeding 24 in. extends every year. The advantages claimed for concrete sewer pipes over vitrified stoneware pipes are, that they are of greater strength; they are more readily and perfectly jointed; they are not liable to split longitudinally under heavy pressure, whilst the tensile and cross-breaking strength of the pipes and joints is very considerably in excess of anything attainable with stoneware pipes. Moreover, they are invariably true in section, whereas stoneware pipes being made under the action of heat twist and warp. Many firms manufacture concrete tubes with steel reinforcement, which adds considerably to their strength, and concrete pipes with special reinforcement have been used for water mains, as at Swansea, Norwich, etc. For sewerage purposes English manufacturers stock pipes from 18 in. in diameter up to 42 in. In conclusion, it should be added that in laying concrete tubes for sewers the ordinary precaution of benching them up in concrete should not be omitted, and that tubes made by manufacturers of good repute should alone be used.—*Sanitary Record.*

CORRESPONDENCE.

43 Parliament Hill, Hampstead, N.W.
June 27th, 1910.

The Editor, "Concrete and Constructional Engineering."

DEAR SIR,—In the account of the "Lecture on Concrete and Reinforced Concrete," delivered by Mr. E. P. Wells, J.P., at the L.C.C. School at Brixton, given in your last issue, Mr. Wells states his views on the initial stresses generated by the shrinkage of the concrete in setting. As the accuracy of his conclusions seems to me, at any rate, somewhat doubtful, I shall be glad if you will allow me this opportunity of stating the case against his contentions.

Mr. Wells is reported as saying, 'Concrete, owing to its nature, did not admit any tension being put into it." A few lines below, Mr. Wells says, "This contraction (of the concrete) puts into the steel an initial compression of somewhere between two and three tons per sq. in. of sectional area." But this compression can only co-exist together with an equal total tension in the concrete, which we are told, will not admit this form of stress. Further, Mr. Wells states that, in beams, this phenomenon is of great advantage, as the beam must be slightly loaded before the initial stress in the steel is overcome; but evidently, once the beam has been loaded to its designed capacity, and the concrete—if the "no tension" hypothesis is correct—has failed under the tension put upon it, the "advantage" is nullified for good. The practical utility of it may therefore be doubted.

In columns, Mr. Wells says, the action is reversed, and the initial stress in the steel is an element of weakness. This conclusion may also be doubted, on considering the fact that the first material to arrive at an unsafe stress in a column is the concrete, not the steel. Any initial tension in the concrete generated by the compression it puts into the steel in shrinking is, therefore, tending towards additional safety, and not detracting from it. For when the concrete is stressed, the greatest permissible amount, say about 800 lb. per sq. in., the steel is receiving only $800 \times 15 = 12{,}000$ lb., or 5⅓ tons, a low and uneconomical stress.

Any factor which tends to increase the stress on the steel whilst relieving the concrete is therefore to be welcomed, and if the shrinkage of the concrete does this, it is an increase to the factor of safety, and not, as Mr. Wells suggests, a menace.

Trusting that this letter will not encroach too greatly on your space.—Yours faithfully,

HERBERT E. STEINBERG.

TRADE NOTICES, CATALOGUES, ETC.

The First Cottbus Cement Goods and Machine Works, whose London depôt is at 1 Laleham Road, Catford, S.E., have just brought out an excellently produced and illustrated catalogue of their numerous specialities. The list is divided into two parts, the first dealing with the various machines used in the manufacture of lime-sand bricks, while the second gives illustrations, descriptions, and prices of machines, moulds and tools for the entire artificial stone and concrete industry. In addition to moulds for the manufacture of concrete fence posts, sewer pipes, and cattle troughs, and machines for making concrete blocks, bricks, tiles, etc., we notice an apparatus for colour spraying, and also one for mixing cement with colouring matter, in both of which a number of our readers will be interested. We should advise all who have not already done so to obtain a copy of this useful list without delay.

Messrs. James H. Tozer & Sons, Ltd., Engineers and Contractors, Birkenhead and London, have requested us to announce that they have appointed Mr. Vere Sussex Hyde, M.C.I., manager of their Reinforced Concrete Department (Lock Woven Mesh system) at their London Office, York Mansion, York Street, Westminster, S.W.

"Ideal" Patent Cork Flooring.—Among the numerous flooring materials which have been put upon the market recently, the "Ideal" patent cork flooring, of which we have just seen a specimen, appears to possess some uncommon features, and will probably be of interest to many of our readers who are in search of suitable coverings for stone or concrete floors. This material, which in appearance is like petrified linoleum or cork carpet, is spread in the manner of asphalt, and presents an absolutely smooth jointless surface, which the inventors claim is rot-proof and waterproof, as well as fireproof, and will not crack nor blister under any conditions. It can be worked to imitate marble or stone and is suitable for covering walls as well as floors. We are informed that among the users of this cork flooring in Germany are Messrs. **Krupp,** of Essen, who gave an order for 10,000 sq. metres, and after having used and tested this for twelve months gave a supplementary order for an additional 18,000 metres. Full particulars of this patent can be obtained from Mr. Curtice, 8 Clarges Street, Piccadilly, W.

CONTRACTS.

Messrs. W. J. Fryer & Co., Bravington Works, Paddington, W., inform us that they have secured the contract for the erection of the Michelin Tyre Company's Factory at Fulham, which is a reinforced concrete structure on a large island site, bounded by roads on all sides, and having an area of 80,000 sq. ft. They also have in hand the Imperial Paper Mills, at Gravesend, which, when finished, will have the enormous output of one thousand tons of paper per week.

ERRATUM.

Owing to a regrettable printer's error, the block showing the beam of uniform strength, which appeared in Messrs. Coignet's advertisement in our June issue, was printed upside down. *See* page v.

"BIC" BRITISH "BIC"
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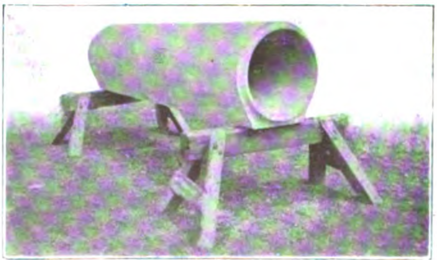
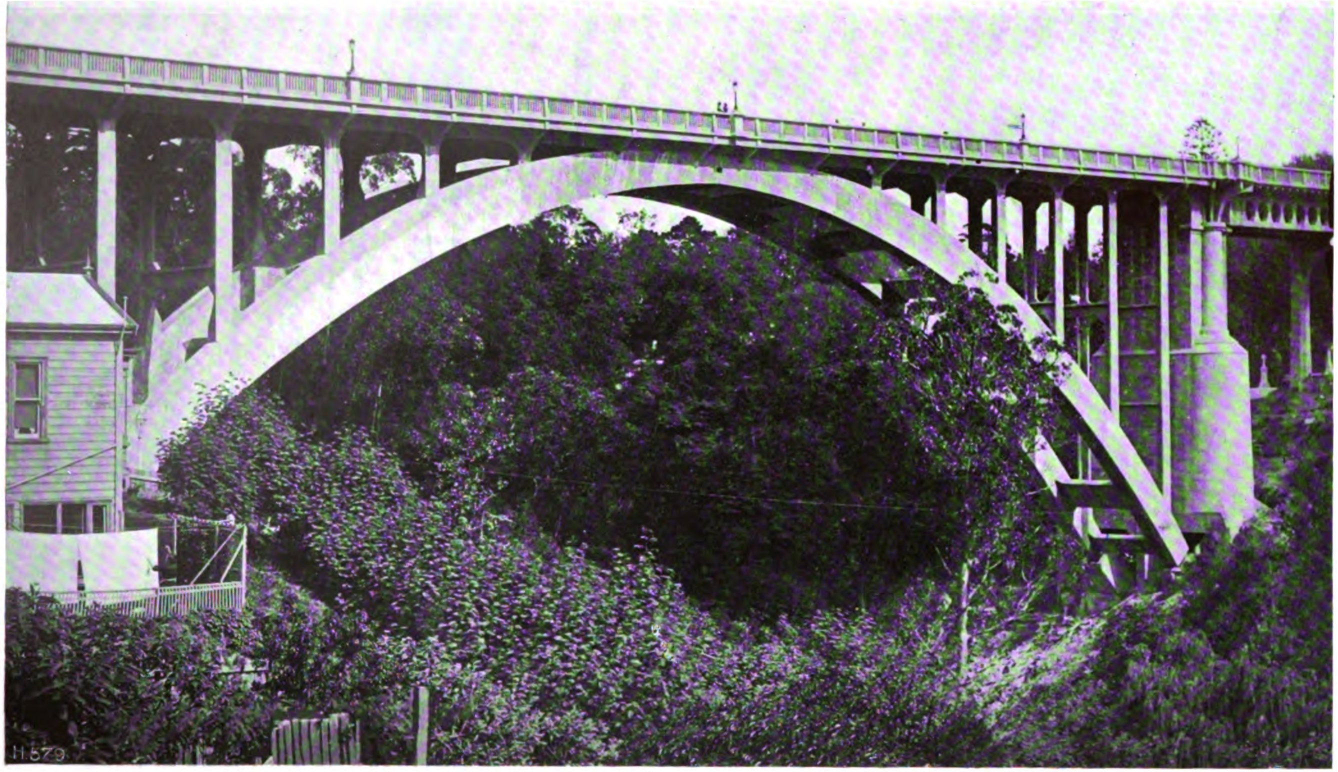
Flat-based Concrete Pipes
Three feet long to Twelve feet long.



Breeze Partitions
Reinforced Sleepers
Telegraph Poles

Porous Pipes
Concrete Beams
Hollow Floors

SPECIALITY:—INVENTORS' DESIGNS CARRIED OUT TO ORDER.



View showing arch span of 320 ft.
GRAFTON BRIDGE, AUCKLAND.

(Frontispiece
Opp. Contents)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 8. LONDON, AUGUST, 1910.

EDITORIAL NOTES.

THE LOCAL GOVERNMENT BOARD FOR IRELAND AND REINFORCED CONCRETE.

A PAPER on "Reinforced Concrete," recently read by Mr. Arthur C. Auden, A.M.Inst.C.E., before the Congress of the Royal Institute of Public Health (Sir Alexander R. Binnie, ex-president of the Institution of Civil Engineers, in the chair), was followed by an interesting discussion, in the course of which Mr. P. C. Cowan, D.Sc.Ed., M.Inst.C.E., the chief engineer, Local Government Board for Ireland, stated that the Local Government Board for Ireland had definitely decided that the time of repayment for loans upon work in reinforced concrete in Ireland should be precisely those for the other building materials.

In this important matter Ireland has certainly shown the way, and we can only hope that ere long our English Local Government Board will adopt an equally fair and common-sense point of view. As we have so frequently indicated, the attitude adopted by this department is an incomprehensible one, and anomalous in the extreme, seeing that some six departments or sections of the Government use reinforced concrete freely, and apply it to public buildings of the greatest importance, which is surely excellent testimony to the high qualities of this material.

The Local Government Board, however, stands aloof, and practically taboos its specification by the municipal authorities it controls, as far as works requiring loans are concerned. This attitude would be absolutely ridiculous were it not of serious moment to the local authorities and the professions and industries affected.

THE NEW ROYAL AUTOMOBILE CLUB.

IN our February and July numbers we published detailed descriptions of the constructional work at the Royal Automobile Club which should specially interest our readers. We have dealt with the concrete foundations, the highly interesting reinforced concrete retaining walls, the constructional steel work and the reinforced concrete floors.

In earlier issues we have described the Ritz Hotel, the *Morning Post* buildings and the Selfridge building. All three are structures of the greatest possible technical interest, but in the Royal Automobile Club we have perhaps the best and the most modern form of combining concrete, steel-frame construction and reinforced concrete.

For various buildings of great extent, simple in plan and containing features that constantly repeat themselves, there is no doubt that the application of reinforced concrete in its entirety is practical and economical, more particularly where these buildings are not subject to legislation, such as is contained in the old provisions of the Building Act or in the " Model Bye-laws," but for the everyday requirements of large structures in populated centres, more particularly where the internal requirements of the structure are of a complex character, there is no doubt that a combination of steel frame and reinforced concrete has very great advantages.

The title of this Journal indicates that its objects are primarily devoted to the uses of concrete in all its various forms, but its sub-title, " Constructional Engineering," plainly indicates that our interest also lies in the direction of steel frame construction.

We certainly believe that for many purposes we shall find in the future that there will be a practical combination of the steel frame building with concrete and reinforced concrete, and we hold that probably the largest possible use of reinforced concrete will be made in structures of this description where the steel framing will support extensive horizontal and vertical surfaces of reinforced concrete.

We, therefore, strongly advocate a greater study of all the general problems relating to the application of reinforced concrete and we think that civil engineers and architects should not omit to carefully study the combination of materials to which we have referred. We believe that all the more important firms concerned in the execution of reinforced concrete will soon be prepared to execute work in which the combination of materials indicated is shown For specialisation—*i.e.*, limitation to reinforced concrete only—has confined the scope of quite a number of reinforced concrete contractors, while some of the older firms who originally devoted themselves to steel frame together with ordinary concrete, have found that their long experience with these two materials has usually led them to adapt themselves very readily to the application of reinforced concrete in conjunction with steel framing and to apply this combination with very great success.

We have been induced to call attention to this matter, having regard to the fact that quite a considerable amount of work is still carried on in steel frame with all manner of makeshifts, such as terra cotta, etc., owing to professional men and building owners believing that they must either take up reinforced concrete for the whole of their structure or leave it alone, and that a combination of steel-frame and reinforced concrete would not be economical. The reverse is, however, the case. The combination of steel-frame and reinforced concrete is economical and in many cases particularly suitable for rapid jobs in large municipal centres.

REINFORCED CONCRETE AND FIRE PROTECTION.

OUR attention has been called to certain cases where buildings have been erected in reinforced concrete with the primary object of affording protection against fire, and where for various reasons this protection is not accorded, owing to the metal bars not being properly and suitably covered by concrete.

We have specific instances before us where the rods in a warehouse floor are not more than $\frac{1}{8}$ in. or $\frac{1}{4}$ in. above the soffit of the ceiling and where the rods in beams are not more than $\frac{1}{2}$ in. to $\frac{3}{4}$ in. behind the outer face of the concrete.

Now, it should be remembered that probably the strongest advocacy for the introduction of reinforced concrete into the United Kingdom originally came from professional men, who saw in reinforced concrete—when properly applied—a fire-resisting material of very great value. Certain of our public authorities who do not insure their buildings appreciated this fact. Various industrial concerns and warehousing corporations, railway companies and harbour boards realised the financial advantage of the fire resistance afforded by properly constructed reinforced concrete buildings. It should thus be quite clearly understood by those who are not giving proper attention nowadays to the subject that if the advantage of fire resistance be eliminated from the list of benefits accruing to those proposing to use reinforced concrete, a very important factor that led to the introduction of the material is omitted. Further, any one serious fire resulting in the collapse of a reinforced concrete structure will mean a set-back for reinforced concrete generally in this country.

It is difficult to say where the fault lies. In some instances the architects or engineers supervising the construction of the building do not give sufficient attention to the necessary protection of all metal work by a proper thickness of concrete, but more frequently, in these days of intense competition, the specialist designers and contractors are obliged to provide the least possible amount of material for reasons of their competitive prices. The very moderate requirements of the Royal Institute of British Architects in this direction are not met in the manner they should be, much less those of the authorities formerly conversant with questions of fire protection. Building inspectors and insurance company surveyors are not sufficiently strict in insisting upon official requirements.

We thus put it to those who are specially interested in the application of reinforced concrete from a business point of view to study the interests of their trade, and to avoid any skimping in the direction indicated. The failure of a building from insufficient fire protection will, in the first instance, not only react upon the designers and contractors employed, but, as indicated above, it will also mean a set-back for the industry as a whole, and, what is more, any uncertainty in the matter or any general unreliability will greatly dishearten some of the best advocates and friends of reinforced concrete.

Given really well designed and properly applied reinforced concrete there is nothing better from the fire point of view than this material, and it would, indeed, be regrettable if confidence were in any way shaken in it.

AMERICAN VIEWS ON REINFORCED CONCRETE.

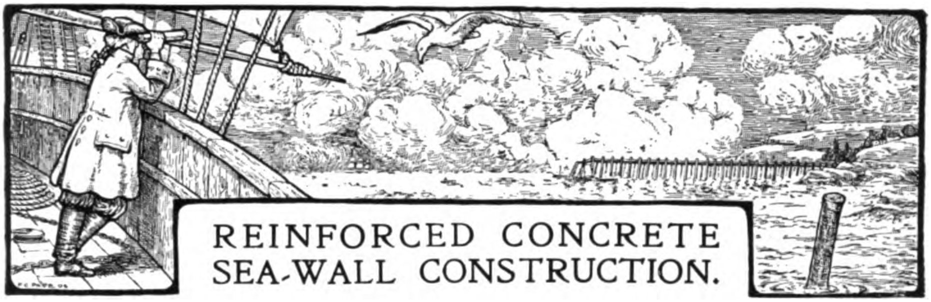
IN our current issue we publish the concluding paragraphs of the Report of the Committee on Reinforced Concrete issued by the American National Association of Cement Users. The first sixty-seven clauses published in our July number dealt with the general aspects of the subject; those in the current issue give the more important details and conclusions.

The report as a whole is an excellent one, although we, of course, do not agree with all the points put forward, and it must be remembered that local conditions very much influence a report of this description.

We were particularly pleased to observe that the report in its third paragraph deals plainly with what is described as the "resistance to external agencies," such as fire-resistance, water-tightness, corrosion, sea-water, acids, oils and alkali, and that the next clause—also given a prominent place at the early part of the report—treat of the all-important question of responsibility and supervision.

The report, in this case, does not come from a professional body or from those who have the control of reinforced concrete structures. It comes essentially from the cement user, who in the American sense constitutes a large majority of general contractors. It conforms, however, to a very great extent with the views of the American professional associations and the Association of American Portland Cement Manufacturers.

The report, we think, carries particular weight owing to its origin. It embodies particularly those features that the cement maker and concrete specialist in America consider to be essentials. As we have indicated on an earlier occasion, we are of the opinion that the report merits very careful attention in this country, more particularly from those who have in hand at the present moment the framing of recommendations or regulations in connection with reinforced concrete structures.



REINFORCED CONCRETE SEA-WALL CONSTRUCTION.

This article, dealing with a novel form of sea-walling carried out at Sydney Harbour, should be of interest to all engineers who are devoting attention to construction under water. The particulars and illustrations were placed at our disposal by Mr. W. E. Adams, A.M.Inst.C.E., who designed the two systems described.—ED.

THE new system of sea walling now being carried out by the Sydney Harbour Trust, at Miller's Point, has been the object of much interest to engineers and others interested in construction under water, this harbour being the first port in which the trestle wall system, here described, has been adopted. Two varieties of this principle of construction have now been tried with equal success, both having been designed by Mr. W. E. Adams, A.M.Inst.C.E., who holds the position of designing engineer to the Sydney Harbour Trust, under Mr. H. D. Walsh, B.A.I., M.Inst.C.E. This system was devised with the object of finding a practical solution of several well-known engineering difficulties in connection with the building of retaining walls, the foundations of which are under water. These difficulties may be briefly summarised as follows :—

1. Work carried out under water is always open to doubt, on account of the obstacles to thorough inspection, and is necessarily much more costly than work done on dry land. Obviously, therefore, it is advisable to perform as much of the labour on dry land, and as little under water as possible. The invention of reinforced concrete, together with the assistance of modern lifting appliances, have together rendered this object attainable to a very large extent.

2. Sea walls, more frequently perhaps than not, are required to be built on indifferent foundations. Even where a rock bottom exists, the cost of a deep gravity section wall is very great, but to build stably on a yielding foundation enhances the cost to a practically prohibitive extent. The concentration of pressure at the toe of a gravity section wall, and the consequent inequality of the pressure on the base, apart from the question of cost, constitutes the greatest objection to walls that resist the overturning moment mainly by their own weight.

The essentials to be regarded in designing a sea wall, therefore, resolve themselves into four factors. Firstly, economy of cost; secondly, avoidance of all unnecessary work under water; thirdly, stability; and, fourthly, a flexibility sufficient to allow the wall to accommodate itself to unequal settlement, and even to lateral movement of the foundations.

Setting out with these several points in view, and taking them in order, it is evident at once that the gravity section wall is extravagant in material. The **L**-shaped section, built of concrete reinforced with steel bars, offers a suitable alternative. The greatly reduced weight of an **L**-section renders it possible for full height vertical sections of the wall to be built on dry land and transported to the foundations, thus avoiding any work under water but the preparation of the foundation. As regards stability against overturning, a very much wider base can be economically secured than in the gravity section wall, and hence greater stability combined with more uniformity of pressure on the foundations. Further, an **L**-section wall built of completely articulated vertical members set up in close contact, each being self-sustaining and capable of individual movement without influence upon the remainder, presents a solution of the flexibility problem. All four factors can, therefore, be secured in this way.

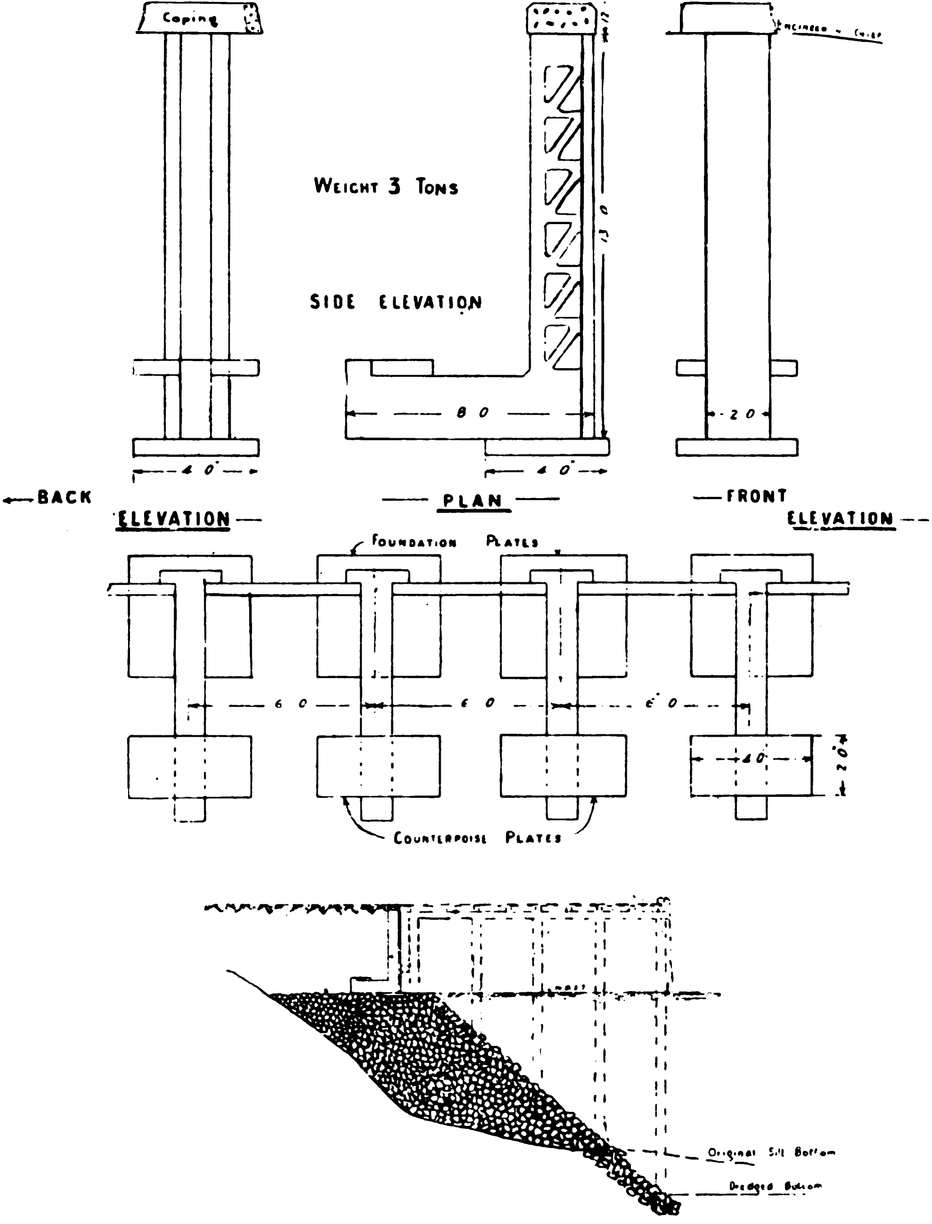


Fig. 1. Reinforced Concrete Sea-Wall Construction, Miller's Point, Sydney Harbour.

Now, it is evident at once that complete stability against overturning can be secured with the **L**-section wall, almost regardless of what it may be placed upon,

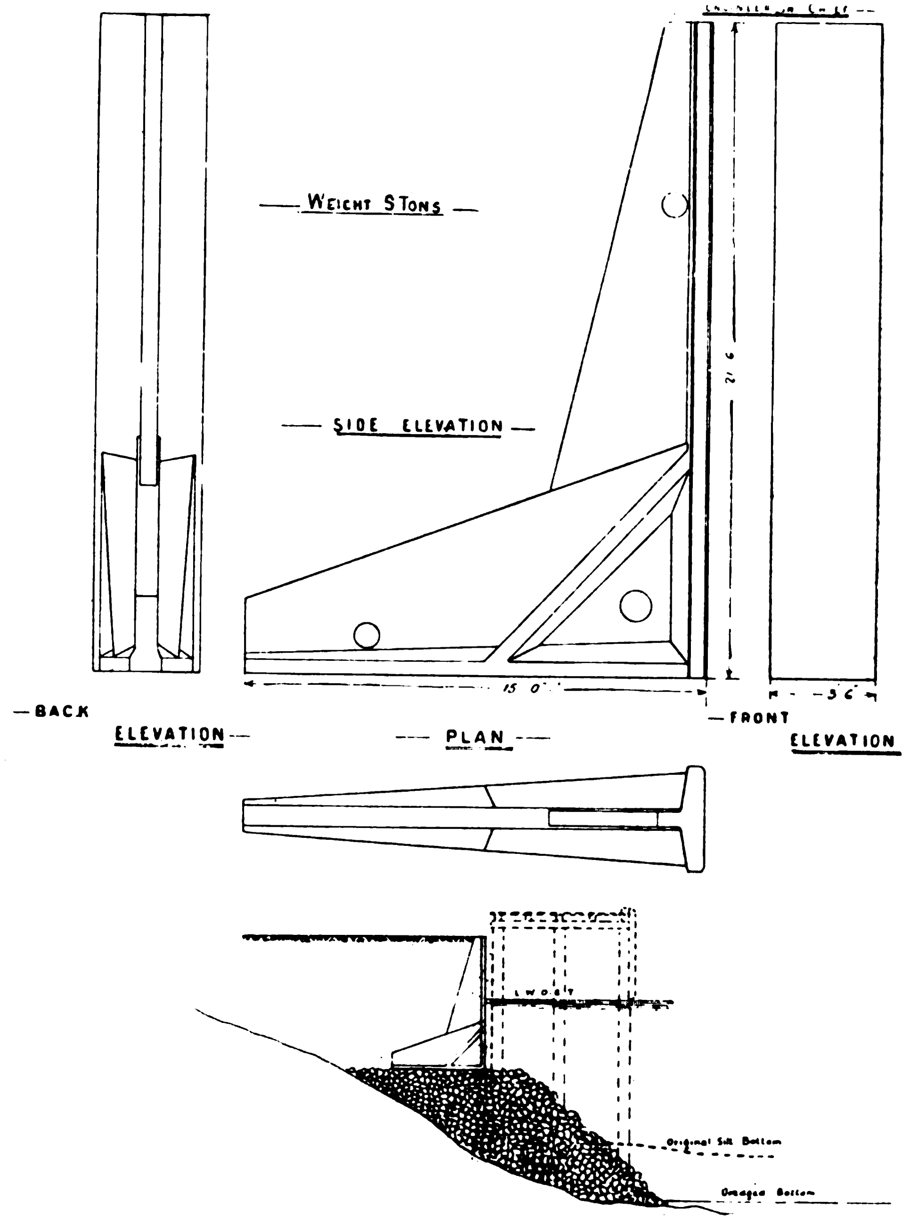


Fig. 2. Another form of Reinforced Concrete Sea-Wall Construction at Miller's Point, Sydney Harbour.

provided only that the foundation is nearly uniform in bearing capacity on lines running transversely to the direction of the wall. Thus, on a foundation of uneven consistency longitudinally, but fairly consistent transversely, a wall can be built secure against overturning and of such flexibility that it will move considerably out of line, both vertically and horizontally, without risk of failure.

In many cases, as, for instance, at the rear of a timber frontage wharf, this is all that is required. The horizontal alignment is not as important as economy of cost, and the want of vertical alignment can be made up by a parapet or coping after settlement has ceased.

Seeing that an almost infinite degree of stability can be secured in the **L**-section wall by lengthening the base member, the question naturally arises as to whether it would not be possible to omit each alternate section or "trestle," and close up the gaps with slabs, or plates, resting against and between the flanges of the trestles. Such a system would obviously effect a considerable saving in the cost of the wall. The next consideration to suggest itself is whether or not more than each alternate trestle could be deleted? The omission of an alternate trestle would necessarily throw an additional load upon those remaining. As the increased pressure would, of course, be transmitted to the foundations, it is in the latter that the limitations will be found. On hard rock the spacing apart could be wide, and as preparation of the bottom is only necessary under each trestle, the saving in labour on foundations would not be less than 100 per cent. On less stable bottoms the spacing apart would be

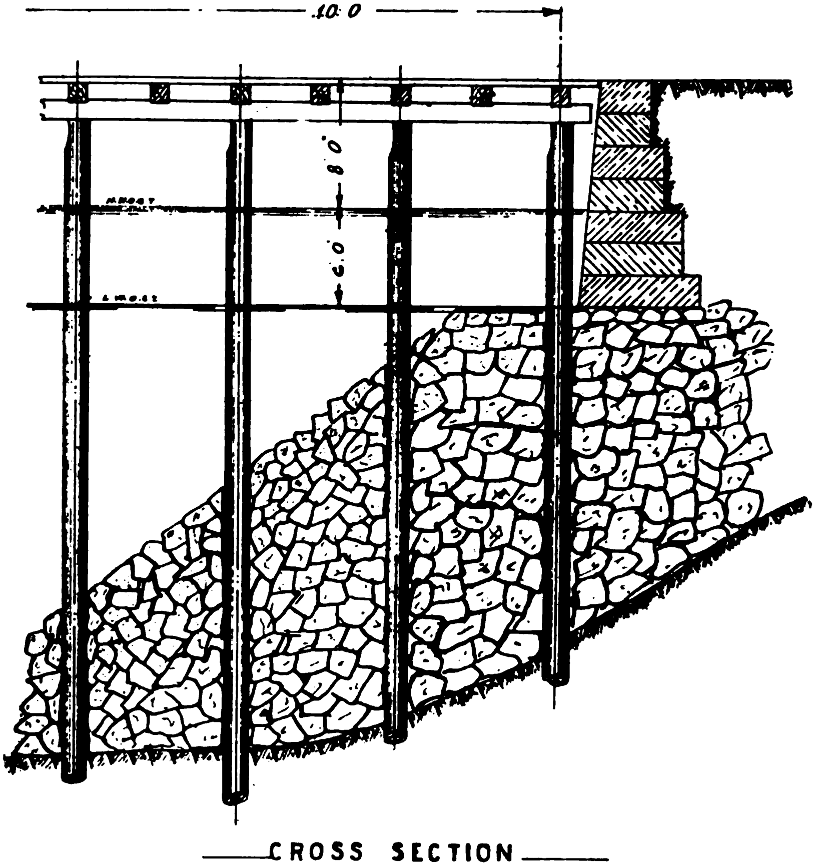


Fig. 3. Cross Section of earlier work at Dalgety's Wharf, Sydney Harbour.

proportionately reduced, and on ballast, or other yielding ground, they could be placed in contact, unless special support be provided at the site of each spaced out trestle, either by driving piles and capping them with concrete, or, where the ground is not too soft, by bedding distributing plates of reinforced concrete underneath.

As the stability of the **L**-section wall is virtually secured by counterpoise, much as we load up the rear legs of a crane, it is apparent that a larger reserve of stability could be acquired by laying a plate upon the end of the base member to react against a larger mass of the filling (see *Fig.* 1).

In view of these several considerations, the **L**-section articulated wall has theoretical advantages that should give it many points of superiority over either the gravity section or the monolithic **L**-section.

The first attempt to put these surmises into practice was made by the Sydney Harbour Trust, in 1907, at the new wharf then under construction at Miller's Point, for the Messageries Maritimes Company. This is a timber wharf 490 ft. long by 40 ft. wide, the deck level standing 14 ft. above low-water mark. A wall was required at the back to retain the filling forming the reclamation. The rear row of piles stood in from 10 to 23 ft. of water at low tide, and at an average distance of 40 ft. out from the original shore line. After the piles had been driven and capped, sandstone ballast was tipped in until the level had been brought up to low water mark. The slope of the ballast under the wharf at one vertical to one and a quarter horizontal then just reached to the front row of piles in 32 ft. of water, as shown in *Fig.* 1. While these works were in progress, tenders were called for the sea walling. Alternative offers were received for :—

(a) Trestle and Plate Wall.
(b) Concrete Block Wall.
(c) Stone Masonry Wall.

The tender for (a), being the lowest, was accepted, the work of setting in place being undertaken by day labour.

The trestles, slabs, foundation, and counterpoise plates were manufactured on the ground with considerable skill and care by the contractors, Messrs. Gummow, Forrest & Co., Ltd., as shown in the photograph, the cost being £3 per lineal foot run of the wall. After the several parts had been given time to set, the ballast was dressed to a level berme extending about 8 ft. beyond the front line of the wall. Beds were formed for the foundation plates by ramming down into the ballast a strong wooden templet, the exact size of the plate, the ramming being done by a 30 cwt. pile-driving monkey suspended from a crane. The templet was then removed, and the foundation plate, shown in *Fig.* 1, laid in the recess and dollied down hard and level, the monkey being again used, care being taken not to damage the plate. At the same time a line of bagged concrete was laid on the ballast under the remainder of the base member of the trestle, and rammed level by hand. The complete foundation being thus prepared, the trestle, weighing nearly three tons, was lifted by crane and swung into its place. It being only possible to work during two hours per tide, at low water, as many of the foundations as possible were first prepared, and when the water began to hinder this operation the trestles were next put into place, and any time that remained over was expended in setting the retaining slabs in place. Sixty lineal feet of wall were thus erected complete in one day, and, had it been necessary, more than double that length could have been set up. The rate of erection in this kind of work is governed entirely by the lifting and dollying plant available.

The reclamation was carried out by tipping soil, ballast, and clay from the cart tail, working out from the shore. No attempt was made to sort or select the materials, except that a small quantity of stone was first packed over the counterpoise plates to hold them in position. No injury was done to the concrete by falling stones, and no hitch of any kind occurred during the progress of the work. Particulars of settlement were carefully observed and noted. During the progress of the filling, which was carried out with only reasonable uniformity, the whole wall sank bodily from 5 to 7 in. A horizontal walling had been placed on the rear row of piles to line the trestles against, and while this probably assisted in maintaining a perfect alignment during the settlement, it is evident, from frequent inspection, that no great pressure was borne by it.

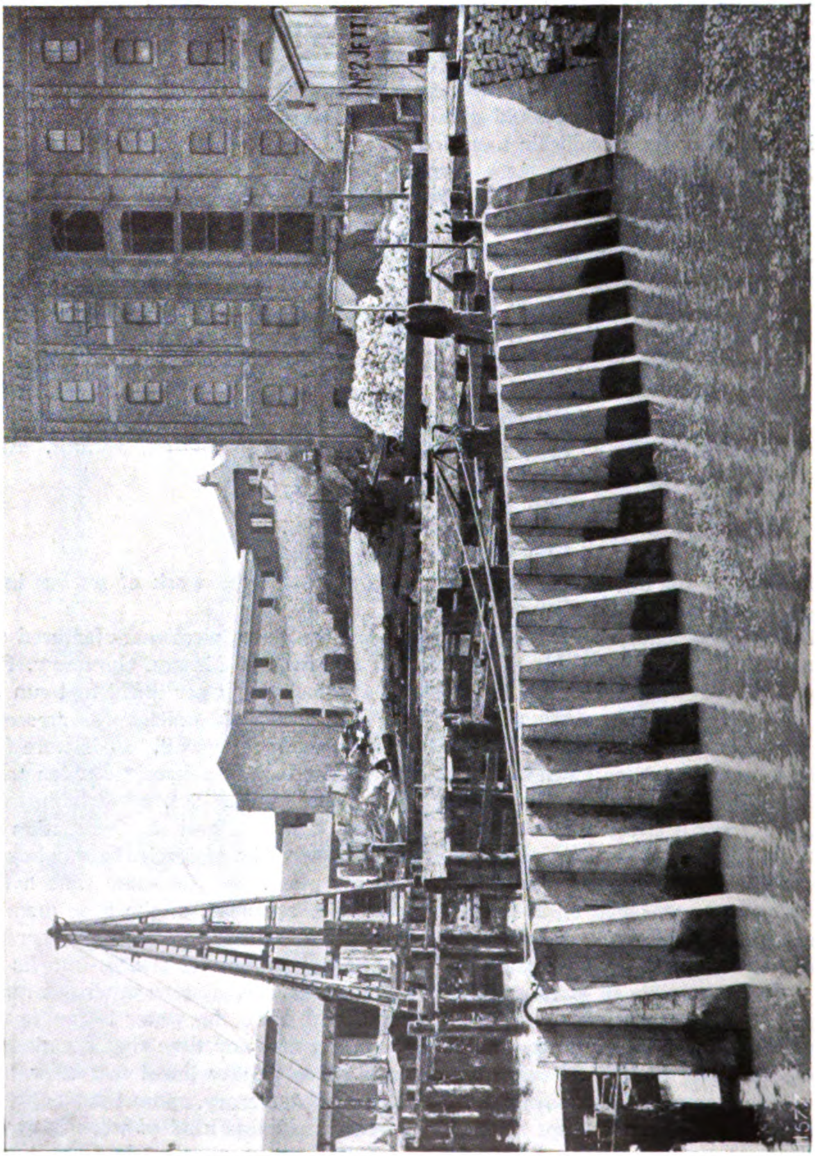


Fig. 4. Portion of Reinforced Concrete Trestle Wall, Miller's Point.

During the first six months after completion of the reclamation the wall settled from 1 to 2½ in., making a total of from 6 to 9½ in., and it has remained stable ever since, a period of nearly three years. The settlement, it might be remarked, is similar in extent to that which occurred at the adjoining wharf (Dalgety's), where a gravity section stone masonry wall of the same height, and 7 ft. 6 in. thick at the base, had been built three years earlier (see *Fig.* 3). But while the unequal settlement of the wall at Dalgety's Wharf caused many of the large stones to break on their beds, the trestle wall remains quite true and fair, and without rupture of any kind, though the filling behind it has sunk in many places as much as 16 in.

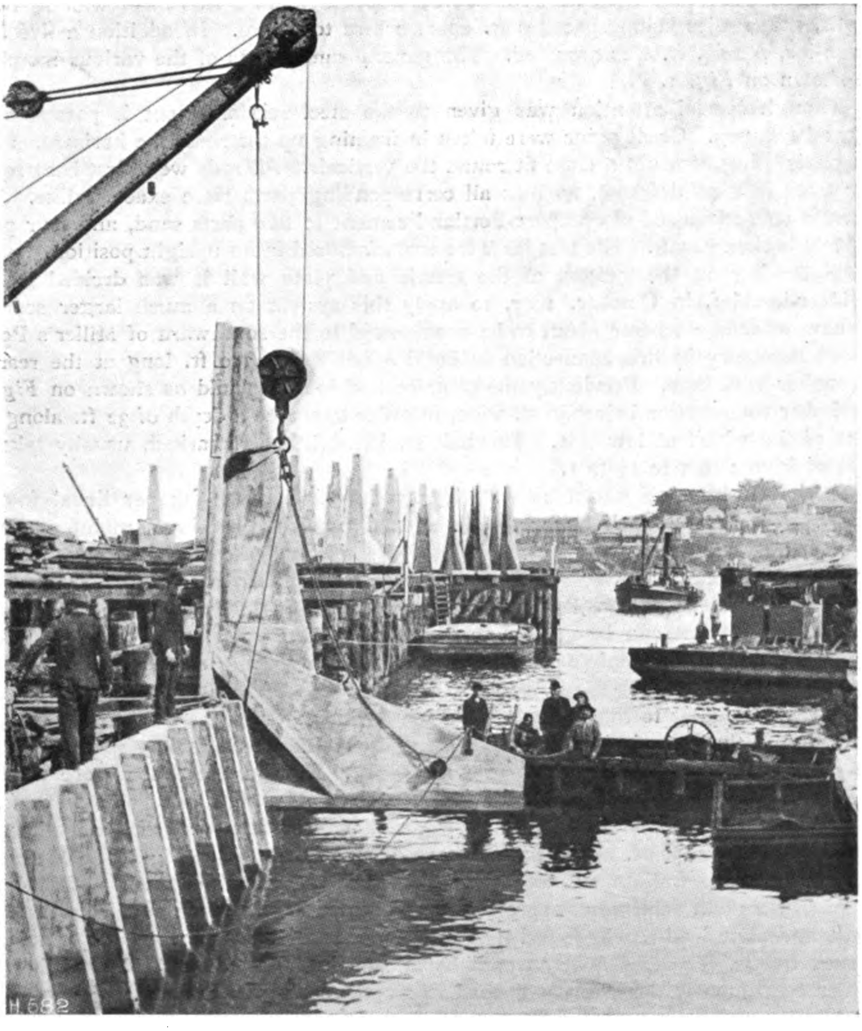


FIG. 5. LOWERING 9-TON REINFORCED CONCRETE TRESTLE INTO POSITION, MILLER'S POINT.

In connection with the designing of the trestles and plates, the following limiting stresses were fixed upon :—

Extreme fibre stress of concrete in compression ...	500 lbs. per sq. in.
Shearing stress in concrete	75 ,, ,,
Direct compression in concrete	400 ,, ,,
Tensile stress in steel reinforcement	16,000 ,, ,,

Pressure on foundation not to exceed 2 tons per sq. ft.

The vertical member of the trestle was designed as a Visintini cantilever, the stresses assured being such as would be developed against 6 ft. run of wall 14 ft. in height, the trestles being spaced 6 ft. apart centre to centre. In addition a live load of 200 lbs. per sq. ft. was assumed. The general dimensions of the various members are shown on *Fig.* 1.

Though special attention was given to the steel reinforcement it possesses no unusual features. Great pains were taken in framing up the rods, the horizontals and diagonals being bent not a close fit round the verticals. All rods were first bent round pins fixed in a solid frame, so that all corresponding parts were exactly alike. The concrete was composed of one part Portland cement to two parts sand, and four parts of finely broken basalt. The trestles were manufactured in an upright position.

Following on the success of the trestle and plate wall it was decided by the engineer-in-chief, in October, 1907, to apply this system on a much larger scale in the new wharfage scheme about to be commenced to the southward of Miller's Point. It was necessary in this connection to build a sea wall 1,350 ft. long at the rear of the timber wharfage. Previously the practice had been to build as shown on *Fig.* 3. the timber construction being 40 ft. wide, in order to secure a depth of 32 ft. along the front of the wharf at low tide. The ballast, it might be remarked, usually takes a slope of from 1 to 1 to 1¼ to 1.

A timber frontage wharf 40 ft. wide at that date cost £15 per lineal foot of length. But timber work being perishable and requiring continual maintenance, it is, of course, advisable to build as little of the timber portion and as much of the permanent reclamation as possible. To dispense with timber altogether would, in one sense, be desirable; but while it is cheap and good it is the most economical class of construction that can be applied to deep water berths. If, therefore, the timber portion were to be built only 20 ft. wide, as shown in *Fig.* 3, there would be available, in lieu of 20 ft. width, £6 10s. per ft. to go towards the cost of a deeper sea wall at the rear. Adding to this £4 per lineal foot, which would be the cost of a sea wall 14 ft. high at the rear of a wharf 40 ft. wide, there would be available £10 10s. towards the sea wall at the back of the 20 ft. wide wharf. The question then arose whether a sea wall could be built for this rate, and in such a way that there would be 32 ft. of water at the berth. Referring again to *Fig* 2, it will be seen that such a wall would require to stand in 12 ft. of water, and have a total height of 21 ft. 6 in. Obviously, a gravity section wall of sufficient bulk to stand upon so indifferent a foundation would cost a great deal more, approximately £13 per ft. In testing the stresses for a trestle and plate wall it was found that the concentrated pressure upon the foundation at each trestle, if spaced apart, would be far too high for ballast; but ranging the trestles contiguously the pressure could be reduced to the permissible limit, 2 tons per sq. ft.

In view of these considerations the work was undertaken, the limiting stresses being fixed as before. The height decided upon for the trestles was 21 ft. 6 in., the width of fall 3 ft. 6 in., and they were required to carry in addition a dwarf parapet wall 4 ft. high with filling behind, and a live load of 200 lbs. per sq. ft. This made the total height to be sustained by the trestles equal to 27 ft. 6 in. Tenders were called in October, 1907, for the construction of the trestles upon the site and the contract was awarded to Messrs. Gummow, Forrest & Co., Ltd., the rate being £8 15s. per ft. run of wall.

The ballast having been completed, leaving a berme of 8 ft. outside the line of the toe of the wall, the preparation and levelling of the foundations was commenced. A heavy ram constructed of two 14 in. by 14 in. iron-bark spars, with flitches at the lower end to increase the area to 2 ft. 8 in. by 2 ft. 8 in., was suspended between the leaders of a floating pile frame. This was raised and dropped upon the ballast until a hard and fairly level surface was obtained. Two old rails were then lowered down and levelled up at 12 ft. below low-water mark, and at a sufficient space apart to accommodate the base of the trestles. The inner rail was kept lower than the outer one, to give the trestles a batter of 4 in. Small shingle was next thrown in and screeded off by divers, using a straightedge with the rails as girders. After the bottom had been thus prepared and levelled up, the trestles, weighing 9 tons, were swung into place by a floating 15-ton crane.

It was found that, including picking up and bringing them to the site and lowering them into place, eight trestles could be set up in one day, or 28 ft. of wall.

The trestles, as well as having a batter of 4 in., were set 9 in. behind and clear of the piles, so that they should not in any way bear against the wharf. They stood upright in the water without trouble, but a temporary strut was always placed at the working ends to prevent accident.

As the load increased to its maximum, signs of settlement, as expected, became apparent, together with slight lateral movement. The ballast, it might be noted, stands upon a sloping bed of still clay, into which it was pressed by the superimposed weight. The settlement varied considerably in extent, ranging from 2½ to 7½ in., and the lateral movement from 2 to 6 in. At one place, where sloping rock lay near the surface, it was not considered safe to put the trestles on ballast. A bed of bagged concrete was, therefore, laid and rammed level, and the trestles set upon this portion did not move when filled up.

It will be seen, by reference to *Fig* 2, that the base member of the trestle tapers towards the rear. This was arranged, firstly, to enable the filling to penetrate below and help to bed the trestle, and, secondly, to allow for swinging, should there be a tendency to creep out of line in setting up.

For lifting, wooden toggles were put through the holes in the webs, shown on the drawing, and wire rope slings slipped over, so that when lowered into the water the trestle assumed a truly vertical position. It might be of interest to note that the centre of gravity in air was not quite the same as in the water, the trestles not being wholly immersed at any time. The correct position of the slings was found after a few trials, and so uniform were the trestles in size and distribution of weight that the slinging position remained constant throughout.

The work of constructing the trestles was carried out by the contractors in a praiseworthy manner, without hitch of any kind, the moulding being done face downwards. The moulding forms were very stoutly framed together of oiled oregon, fitted in panels in such a way that the whole could be taken apart when the moulding was finished.

The steel reinforcement was put together complete, and set up in place ready for enclosing in the moulding forms. The diagonal and cross ends were wrapped, not a close fit, round the vertical rods, and the whole, when framed up, formed a rigid skeleton, capable of being moved about. The steel rods were supplied by Messrs. G. & C. Hoskins, Ltd., of Lithgow, manufactured from Australian ore.

The concrete was composed of one part of cement to two parts of sand and four parts of finely broken basalt.

The first portion of the wall built has now been standing eighteen months, and is in perfect condition.

THE CHOICE OF REINFORCEMENT.

By a Correspondent.

The choice of a suitable reinforcement in reinforced concrete work is a matter of the utmost importance, and the present contribution on the subject calls for attention.

Views on the subject are still very divergent, and those associated with the sale of special forms of bars are apt to take an optimistic view of the value of their particular specialities.

We do not associate ourselves with the views expressed in this article, either for or against, but we are always pleased to publish both sides of a question of this sort, and we shall, therefore, gladly open our columns for correspondence or articles.—ED.

THE architect or engineer wishing to execute a structure in reinforced concrete generally finds it convenient to submit his problem to one of the many specialist firms controlling different systems, and to invite them to prepare a design for him on their system. It must be admitted that these specialist firms do produce very good designs, and generally at a very low cost, since their designers are usually able to obtain a very large experience, and, in the case of large firms, it is frequently possible to enable a man, not only to specialise in reinforced concrete, but also to specialise in its application to a particular kind of structure, such, for instance, as grain silos, bridges, reservoirs, factories, etc.

There are, however, a large number of different systems between which an architect or engineer will have to make a choice, and to do so it will be necessary for him to consider the relative merits of the different systems on the market. The very fact of so many systems still being used exclusively by specialist firms shows that a large number of questions have not been solved, at any rate, from a commercial point of view. Though no doubt every system has some advantage, no definite conclusion has yet been arrived at as to which system gives the greatest advantage when all points, including economy, are considered. In this connection we may remark that it will be difficult for an engineer who has not specialised very much in reinforced concrete work to determine the relative merits of systems by inviting tenders on these different systems, since generally he is not able to determine the exact factor of safety of a particular design with sufficient accuracy. It is, therefore, of the greatest importance that engineers and architects should acquaint themselves sufficiently with the principles of reinforced concrete to enable them to consider the merits of a system.

It will be found that in any attempt to compare the inherent advantage of one system with another several considerations are involved, and usually that one question cannot be solved satisfactorily without the same time considering cognate questions.

A matter of great and obvious importance is the use of high carbon steel in reinforced concrete work. The use of this material in steel structural work has practically been abandoned except in a few special cases. It does not, however, follow that it is unsuitable as a reinforcement to concrete. The objections to its use in structural work are chiefly the difficulty experienced in working it, and the danger of its becoming brittle under sudden application of load, especially in places which have been subjected to hammering or similar processes. With reinforced concrete neither of these objections hold with anything like the same force as with structural work, since in the first place the only fashioning which is necessary is confined to bending, generally to a large curve. It is found as the result of experience that the cost of bending a ton of reinforcement is very much less than the cost of labour on a ton of structural work, and, therefore, even if the use of high carbon steel increased this cost of bending considerably, the increase in cost on the whole job would be only a small percentage. But, as a matter of fact, it is found that the cost of bending high carbon steel is not appreciably more than that of mild steel, for when large sections of either are heated the expense is the same, while for small sections a simple bending machine reduces the outlay to little more than that necessary for setting out the bends. In addition to this, it will be seen later that the use of high carbon steel is only justified when a mechanical bond is provided, and in that case the amount of bending required per ton can be considerably reduced, since a great many hooks can be obviated, their places being taken by the mechanical bond of the bar.

In the second place, the objection to the use of high carbon steel, because of its brittleness after being fashioned, is very largely reduced owing to the limited amount of such fashioning which is necessary.

Where large bars are used, and of course bent when hot, there exists no danger from this cause, and in the case of small bars the radius of the bend is generally large compared with the diameter of the bar. It should also be noted that the bends are usually located at points where the stress on the bar is considerably below the maximum, as for instance where bars are bent up from the bottom of the beam towards the end.

Furthermore, the massiveness of reinforced concrete compared with that of steel work has the effect of considerably reducing the vibration. This is an established fact, which is appreciated by cotton-mill engineers and others in charge of machines of a similar nature where vibration is extremely detrimental.

Having taken the attitude that the old objections to high tensile steel do not apply to its use as a reinforcing material for concrete, we must examine, *de novo*, the advantages and objections which its use for this purpose entails. In the first place, high carbon steel, suitable for this class of work, with an ample elongation in fracture, may be obtained with both the elastic limit and the ultimate stress increased by some 25 per cent. above the corresponding values for mild steel, and it therefore follows that for the same factor of safety a reduction of 20 per cent. in the quantity of steel required in any given member is generally permissible. As the increase in cost of this steel is much below the increase in strength, it follows that its use will be economical provided the stress is increased in proportion to the increased strength. But here we are met with the objection to the use of high carbon steel, stressed to correspondingly increased stresses. It is a well-established fact that concrete will not stand without cracking the percentage elongation which takes place when steel is stressed to 16,000 lbs. per sq. in. These cracks are generally small, in fact, hardly visible, and certainly not large enough to allow rust to get at the reinforcement, but at a stress of 20,000 lbs. per sq. in., which the use of high carbon steel warrants, the increased elongation causes larger cracks to appear, too large, in fact, to insure immunity from the danger of rusting. They also extend further up into the beam, thereby increasing the danger of the beams failing by shear or diagonal tension, which is particularly dangerous, on account of the absence of any kind of warning.

These objections are sufficiently serious to practically prohibit the use of a high carbon steel at correspondingly high stresses, except when special provision is made to reduce these cracks, and this accounts for the large use of mild steel for reinforcing work. How to reduce the size of cracks becomes fairly clear when it is understood that they cannot appear without some slipping of the steel. This slipping may be for a considerable length or it may only be local. In the case of a beam in which the steel is stressed up to such a point that cracks are formed in the concrete near the centre of the beam, a little consideration will show that the width of a crack represents the elongation of just such a length of steel as has slipped. On the gradual application of the load to the beam, the steel and concrete at first stretched together and continued doing so until the concrete would stretch no further without fracture, and when this took place the concrete on each side of the crack would be suddenly released from its load, returning, as a consequence, to its original length. On further increase of load the steel continued to stretch, and the size of the crack increased.

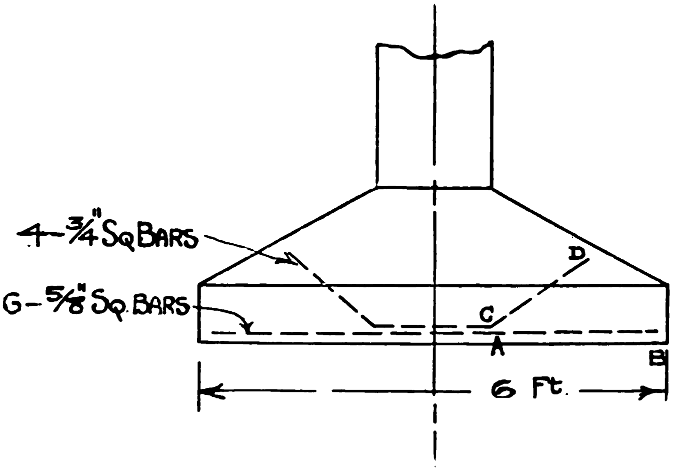


Fig. 1. Typical Design of Reinforced Concrete Footing.

It becomes fairly easy, therefore, to get an idea of what length of concrete must slip to enable a crack of any given size to form for a given stress in the steel. For a stress of 20,000 lbs. per sq. in. the extension in the steel per inch length is $\frac{20000}{30000000} = \frac{1}{1500}$ in., and consequently a crack of $\frac{1}{100}$ in. involves slipping, however small, on a length of $\frac{1500}{100} = 15$ in., about half on each side of the crack. It may be seen, therefore, that the use of bars giving a mechanical bond by the provision of indentations or projections will limit the possible slipping to that between the projections, and consequently the size of cracks will be correspondingly reduced. Thus, if the indentations prevent the concrete from slipping for more than 3 in. the cracks will not exceed $\frac{1}{500}$ in. in thickness. Naturally, the number of cracks will increase, the effect of the mechanical bond being to distribute them over the length of the beam, substituting a large number of extremely small and short cracks, which are quite harmless, for a smaller number of larger cracks, which may be dangerous, both because of the probability of rusting, and also because they extend further up the beam, thus increasing the danger of sudden failure by diagonal tension.

It will be seen, therefore, that the use of high carbon steel can only be economical in conjunction with mechanical bond, and from a commercial point of view, instead of two questions—high carbon *v.* mild steel, and deformed *v.* plain bars—there is only one to be decided, *i.e.*, deformed bars of high carbon steel *v.* plain bars of mild steel.

Even if it could be shown that plain mild steel bars always gave ample bond resistance, it follows from what has been pointed out that high carbon deformed bars are economical as compared with plain mild steel bars, provided the increase in the cost does not exceed about 25 per cent.*

But there are other considerations which, on the whole, would favour the use of deformed bars, even if the cost were increased 25 per cent. Besides the important reduction in the size of cracks, it can be shown that the use of plain rods does not always give sufficient resistance against slipping. Probably, one of the most striking examples of this, which frequently occurs in practice, is in the case of footings. *Fig.* 1 shows a design for a footing 6 ft. square. To resist the BM on the footing, the $\frac{5}{8}$-in. bars will be stressed to 20,000 lbs. per square inch at the point A, and this stress is gradually reduced to zero in the length A-B.

Tension per bar = ·31 × 20,000 = 6,200 lbs. Surface area in A-B = 26 in. × 4 × $\frac{5}{8}$ = 65 sq. in.

Mean adhesive stress along A-B = $\frac{6200}{65}$ = 95 lbs. sq. in.

Referring to the $\frac{3}{4}$-in. bars bent up to resist shear—

Tension per bar = ·44 × 20,000 = 8,800 lbs. Surface area in CD = 18 × 4 × $\frac{3}{4}$ = 54 sq. in.

Mean adhesive stress = $\frac{8800}{54}$ = 163 lbs. sq. in.

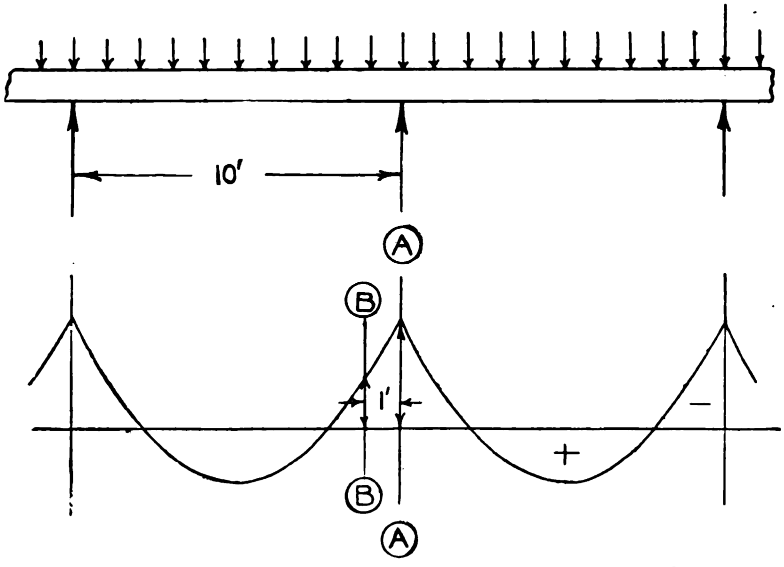


FIG. 2. BENDING MOMENT CURVE OF A CONTINUOUS BEAM WITH UNIFORM LOADING.

The adhesion of plain rods in concrete has been the subject of a large number of experiments, it being found that the ultimate value depends a great deal on the conditions under which the test is made. An ultimate adhesion of about 400 lbs. per square in. was found for a large number of tests, in which bars were pulled out from a block of concrete, and, therefore, the value of 100 lbs. per sqare. in., recommended by the R.I.B.A., seems sufficiently safe. It has, however, been shown since that these high values were largely due to the lateral spreading of the concrete, which, from the conditions of the tests, was compressed as the load on the rod increased. Tests by Professor M. O. Withey[†] show that when the bar is pulled out from the end of a beam, as in practice, where this lateral compression of the concrete is not developed, the adhesion is much less, about 276 lbs. per square in. in 60 days, and in view of this it would seem that the 100 lbs. per square in. allowed by the R.I.B.A. gives a factor of safety of considerably less than four, and, in fact, the American Joint Committee limited the bond stresses to 80 lbs. per square in.

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* This increase in cost must, of course, be taken on the actual price of the steel without the inclusion of any charges for designs, as it is the custom of some companies to include in the price per ton a percentage which on the average pays for the cost of designs; this must, therefore, be deducted when making comparisons.

It will, therefore, be seen that the actual bond stresses in the footing referred to above (93 and 163 lbs. per square in.) are greater than can safely be taken without the use of deformed bars. Many other similar cases occur in practice, especially in the case of short or heavily-loaded beams, where the ratio of shear to bending moment is high. The bond stresses are often high in the bars resisting the reverse bending moment over the point of support on a continuous beam, owing to the steepness of the bending moment curve at this point. *Fig.* 2 illustrates this. As an example, take the case of a continuous beam of 10 ft. span loaded with 3,000 lbs. per foot run.

BM at AA = $\frac{2}{3} \times \frac{wl^2}{8}$ = 300,000 in lbs.

BM at BB = 103,200 in lbs.

if BB is taken one foot from AA.

With a beam 13 in. deep, depth from centre of steel = 11 in.

If the reverse BM is taken by two 1-in. diameter bars (which will be stressed to 20,000 lbs. per square in.)

Total tension at A = $\frac{300000}{9\frac{1}{2}}$ in. = 31,500 lbs., and

Total tension at B = $\frac{196800}{9\frac{1}{2}}$ in. = 20,700 lbs.

Hence difference in tension = 10,800 lbs. Superficial area of two 1-in. bars, between A and B = 24 × 3·14 = 75 square in. Hence average adhesion stress = $\frac{10800}{75}$ = 144 lbs. per square in.

It will be seen that this stress is greater than can be safely resisted by plain rods. It is important to realise that it is not sufficient to anchor the bar at the end by means of a hook, fished end, or the like. The statical conditions give a certain bending moment curve for a beam, say, and it is tacitly assumed in the formulæ by which reinforced concrete is designed that the stress in the steel will at anv point be just what is required to resist the bending moment. That is, the stress must gradually increase in the bar as does the bending moment. If the adhesion is deficient, and reliance is placed on a hook at the end, this condition is not realised, and the formulæ are then based on assumptions no longer true. Apart from this, it can be shown that although a hooked end may fix the end of the bar when the hook is embedded in a large mass of concrete, it is of very little use when only a small thickness of concrete exists around the hook, since the hook produces a wedging action, which bursts the concrete. Tests of hooked ends have generally failed, by the bursting of the concrete block in which the hook was embedded, even when these were as large as six and even twelve inches square. Since, in reinforced concrete, the steel reinforcement is very much nearer to the surface, it will be seen that very little reliance can be placed on hooks, except in special cases where it becomes possible to place the hook where this bursting action can be prevented. This bursting action is very much reduced by the use of deformed bars, if not entirely obviated. There can be none if the surface of the projections on the bars is at right angles to the axis of the bar, and if the inclination of the projection is only slightly less than 90° this bursting action will not be felt, it having been overcome by the static friction of the concrete against the projections.

[†] Proc. Am. Soc. for Testing Materials, 1909.

In any case, it is certainly better to distribute this bursting force in the concrete over a large length, for it must require a larger force to burst the concrete round two feet, say, of bar, than to burst it for a few inches, which is all that is required where a hooked end is used.

In cases subjected to considerable temperature stresses the value of deformed bars is great. As an example, to show roughly what dimensions such stresses can have, take the case of a long structure fixed at the ends, where the contraction in cold weather has to be taken up by a tensile stress, or by the formation of cracks.

For a contraction of 1° Fahr., decrease in length = ·000,0067.

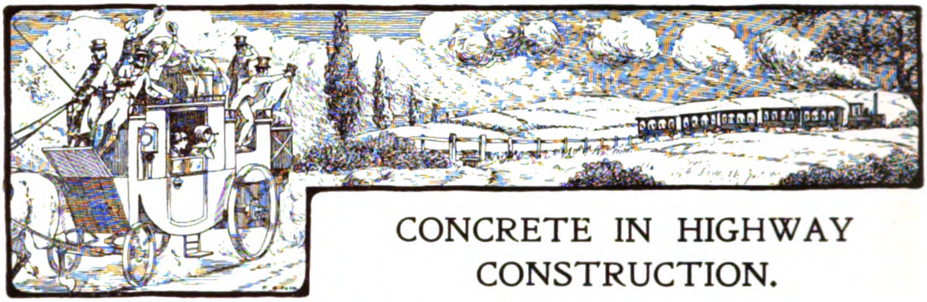
The stress required to overcome this without the formation of cracks

$$= \cdot 000{,}0067 \times 2{,}000{,}000 = 13\cdot 4 \text{ lbs. per square in.}$$

Taking 200 lbs. per square in. as the ultimate stress of concrete, it will be seen that the maximum reduction of temperature which can be experienced without the formation of cracks is about $\frac{200}{13\cdot 4} = 55^{\circ}$ Fahr. Since, however, the concrete will be subjected to an initial tensile stress, in virtue of its contraction during setting, the actual reduction of temperature which it will stand without cracking is considerably less than this in favourable conditions, and where any stresses are imposed by the conditions of loading—as, for instance, by unequal settlement—any reduction of temperature is followed by the formation of cracks. The object of the reinforcement is to distribute the cracks, and make them so small that they do not matter, and, as has already been shown, deformed bars will do this very effectively indeed, since the thickness of the hair cracks is limited to the reduction of length of the concrete between two projections on the bar, and will therefore be almost infinitesimal.

Whether the adhesion of concrete to plain round rods is reduced by vibration, extending over several years, cannot yet be definitely asserted, but it is certain that the use of deformed bars carries with it a guarantee that the adhesion will be ample, even if the circumferential tension in the concrete round the bars—produced by the contraction of the concrete during setting—on which the adhesion of plain rods depends, were to become less by constant vibration, percolation, or the formation of cracks from any cause.

It will be seen from what has been said that the choice of a reinforcing bar involves a great many cognate questions, which react upon one another, the chief of these being, perhaps, the use and economy of deformed bars, and of high tensile steel, and the extent to which cracks can be permitted; and that if deformed bars can be obtained at a price not exceeding that of ordinary bars by more than the percentage increase in elastic limit—somewhere about 25 per cent.—they will be economical, apart from many other advantages which their use confers.



CONCRETE IN HIGHWAY CONSTRUCTION.

The application of concrete to all highway and road work is receiving such attention in the United States at the moment, that numerous minor publications on the subject have recently been issued. Amongst these is a comprehensive one published by the Atlas Cement Co., of New York, from which we are presenting some extracts.

The new Road Board might well study the question of using concrete more freely on our highways, for practical and economical reasons.—ED.

Concrete has been used for many years past in the construction of roads and pavements, but its application has been limited almost entirely to the foundation work alone and it has probably never been considered as indispensable or by any means the most important factor in the construction of a highway. Of late years, however, it has been much more extensively employed, and particularly where permanent and better roads and sidewalks of a durable character have been required. The great increase in the use of automobiles, with disastrous effect on many roads, and the development of manufacture in all parts of the country, has led many engineers to design and carry out highways and pavements of a far superior nature to those constructed a few years ago, and concrete has been extensively employed not only for culverts, bridges and retaining walls in connection with the highways, but also for the construction of the road itself, either as a foundation for a stone, brick or asphalt surface, or a complete pavement, including foundations and wearing surfaces. For sidewalks, curbs and gutters its use is becoming quite universal, while as a material for drain tiles, lamp posts, fence posts and many other highway appurtenances its value is quickly being recognised, as is shown by the great increase in its use for such purposes. In the building of park structures, drinking fountains and seats its use has been accelerated on account of its cheapness and the ease with which it can be moulded into artistic forms.

The examples described in this article are principally taken from America, where the development has been far more rapid than in this country, owing to the fact that more new highways have been required in the former during the past few years, and this has given more scope for the application of a material the merits of which have until recently never been fully realised.

Wood, steel, stone and concrete are, generally speaking, the principal materials employed in the construction of highways, bridges, culverts and such like, and of these four materials wood is usually the cheapest in the first cost for small structures in America, but is the least durable of all. It cannot be considered seriously as a material in any first-class construction of importance and is now seldom employed. Stone is very durable, but its first cost and scarcity in many districts tend to limit its application to highway construction. It is also expensive to work into the desired forms when repetition is required. Steel, of course, is an important material, particularly in the construction of highway bridges, but its cost and heavy maintenance expenses, if properly painted to prevent deterioration, are such that concrete is in many cases superseding it.

Concrete combines cheapness with durability and is easily adapted to any shape or position. It can be made in any locality and can be placed in the work with very little skilled labour, providing efficient supervision is maintained. The aggregate and matrix should be carefully proportioned to suit the particular work for which it is employed, it should be thoroughly mixed and carefully laid, the cement should be of a good quality and the aggregate clean, when the results obtained will always justify the selection of concrete for constructional work.

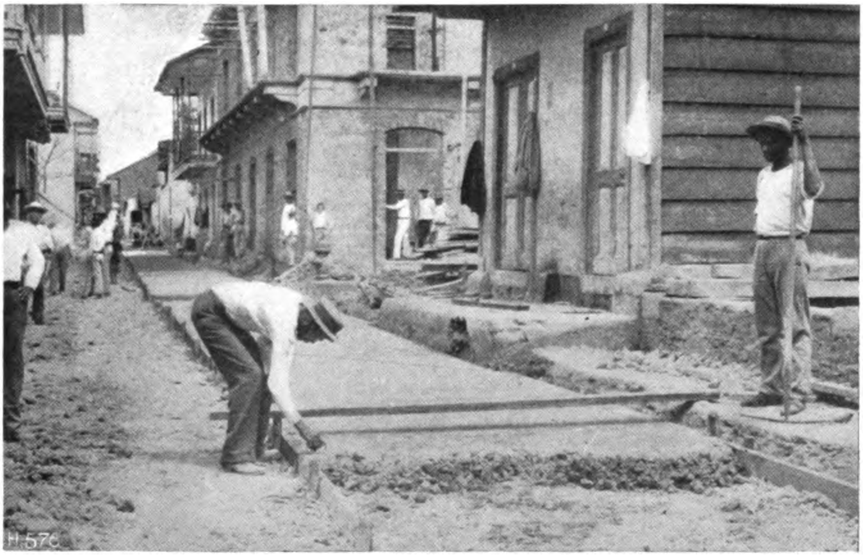


FIG. 1. CONCRETE PAVEMENT IN COURSE OF CONSTRUCTION IN CITY OF PANAMA.

SIDEWALKS, CURBS AND GUTTERS.

The essentials of a good sidewalk are that it should be smooth, durable, cheap in the first cost, and present a pleasing appearance. With proper care concrete can be laid to satisfy all these requirements, and it has been utilised extensively. For curbs alone, or for combined curbs and gutters, especially for streets in residential districts, parks or similar places, where neatness of appearance is especially desirable, concrete is being used in many localities almost exclusively. A first-class walk consists of a foundation of cinders, gravel or broken stone, upon which is placed a layer of cement concrete, called the base, and an upper thin layer, called the wearing surface, usually of granolithic. The width of a sidewalk, of course, varies according to the requirements, but the thickness of the concrete employed is practically uniform, ranging from 4 in. to 5 in., including the wearing surface. Where the total thickness of the concrete is 4 in. the base should be 3¼ in. or 3 in. and the wearing surface ¾ in. or 1 in., and for a 5-in. thickness the base should be 4 in. and the wearing surface 1 in. The cinder or gravel foundation should be about 8 in. in thickness and proper drainage should be provided. The fall of the surface toward the curb should be about ¾ in. or ⅜ in. per foot. Curbs are made from 6 in. to 8 in. wide on top and are generally vertical on the side next to the path and slightly inclined on the side facing the gutter. The total depth of the curb should be from 12 in. to 14 in., and if the street traffic is heavy the curb should be set on a concrete base 12 in. wide and 8 in. thick. Where the curb and gutter are combined the gutter is made 8 in. thick and from 1½ ft. to 3 ft. in width. The upper outer corner of the curb and the intersection of gutter with face of curb should be rounded off with radii of about 1 in. The surface of the gutter usually conforms to that of the road surface, but in some cities, such as Salt Lake City, the upper surface of the gutter is curved in such a manner as to secure greater carrying capacity, the depth of the gutter being 10 in., whereas it would be only 8 in. were the curve omitted and the slope of the street continued to the curb line.

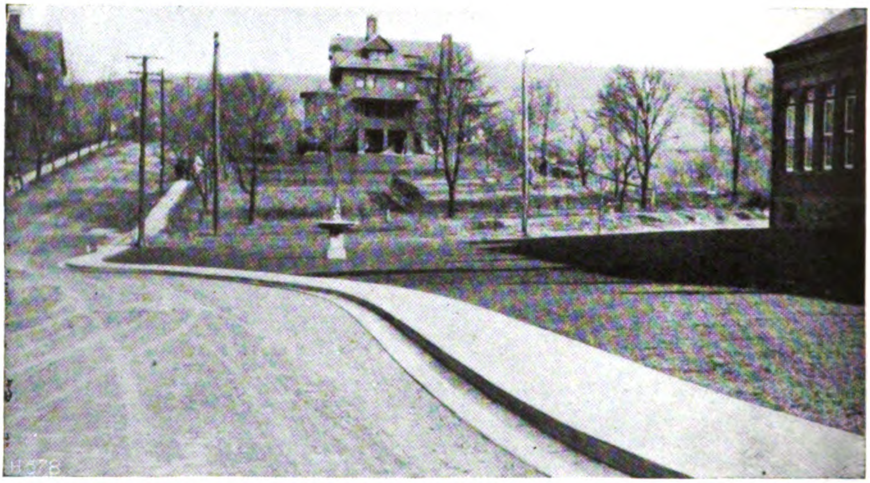


FIG. 2. CONCRETE SIDEWALK IN SOUTH BETHLEHEM, PA.

It is absolutely essential that a good foundation, properly drained, should be provided in sidewalk construction, and this is best accomplished by excavating the soil to a depth of 10 in. to 15 in. below the level of the finished surface, so as to give a foundation 6 in. to 10 in. thick of broken stone or cinders, which should be thoroughly rammed in position. The photograph (*Fig.* 1) shows a pavement during construction in the City of Panama.

The concrete for the base should be mixed with 1 part Portland cement, 2½ parts sand and 5 parts broken stone or gravel. A good wearing surface is made by mixing 1 part Portland cement with 1½ parts sand to such a consistency that it may be simply floated with a straight edge without any tamping. The sand may be either pit sand or crushed stone which will pass a ¼-in. screen, provided a hard stone is used which has but little dust. The wearing surface is frequently made with 1 part sand and 2 parts of fine aggregate, but this mixture is liable to make a surface that will wear sandy. To ensure good results and prevent the wearing surface from eventually cracking from the base it is absolutely essential that the mortar be spread before the concrete base has begun to stiffen, for if it is left for several hours or over night the wearing surface is almost sure to peel off in places. After smoothing the wearing surface with a straight edge float it roughly with a plasterer's trowel, and after a few hours, when the mortar has begun to stiffen, float it with a wooden float and then with a metal float. Joints can be made across the walk just as the final floating is being finished and if a roughened surface is desired a dot roller or a grooved roller may be used. The walk should be protected from the sun for at least four days and wetted frequently. *Fig.* 2 illustrates a finished concrete sidewalk in South Bethlehem, Pa. By selecting a crushed stone of the proper variety a permanent colour can be secured for the surface of a walk and artificial colouring can be obtained by the addition of lamp black, ochre, iron oxide and other materials to the cement, but most of these colours will fade.

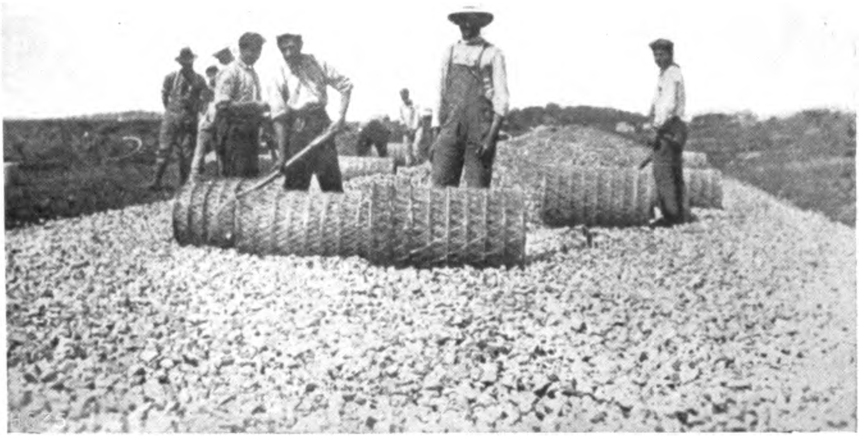


Fig. 3. Construction of Long Island Motor Drive.

ROADWAYS.

The ideal street pavement is durable, noiseless, cleanly, easy to travel on, low in first cost and built of such materials that little maintenance is required. Portland cement concrete has been used with great success in recent years, and although as a material for the wearing surface it is comparatively new, it is used almost exclusively for the foundation work. With regard to cleanliness, it successfully resists the action of manure when thoroughly hardened, although green concrete is injured by such action on account of the acids present in the manure. Probably the first street pavement of concrete was that built in Richmond, Ind., in 1903, on Sailor Street, and in 1906, when it was necessary to cut a trench the entire length of this roadway for telephone conduits, the concrete was found so hard that it could only be cut with great difficulty.

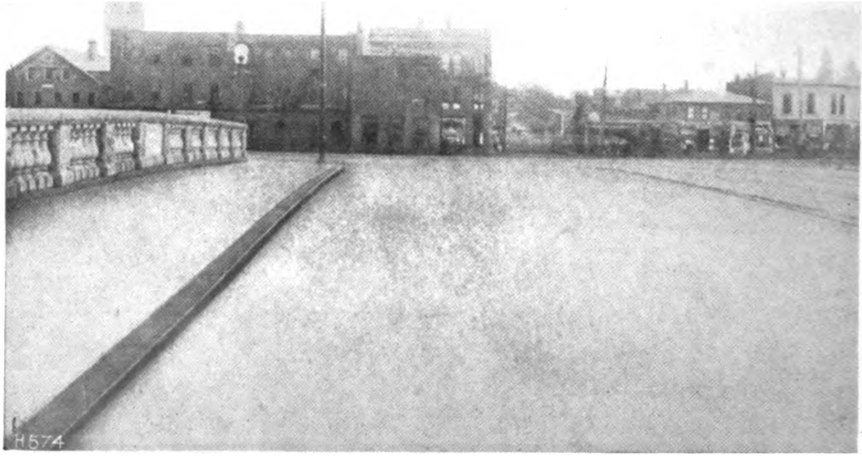


Fig. 4. Road at Watertown, Mass.

On the completion of the conduit the pavement was repaired, and in 1908 it seemed to be as good as when laid in 1903. It is absolutely necessary that a first-class aggregate should be used for the wearing surface, otherwise the results will not be satisfactory. The item of smoothness is to a large degree under the control of the engineer when concrete is adopted, as the surface can be grooved or roughened as required, and this is particularly advantageous on a steep grade. In foundation work the subsoil should be properly shaped and graded and then thoroughly rolled with a steam roller weighing not less than 10 tons. The thickness of the concrete foundations should be 6 in. and the proportion will naturally depend upon the local conditions, the most general mixture being composed of 1 part cement, 3 parts sand and from 5 to 7 parts of broken stone or gravel. Owing to the increased use of concrete highways certain companies in America have made a speciality of this work; one of these is laid in the form of a grouted macadam street, or as a granite block pavement on a grouted macadam foundation, and in each case the work is done in a manner peculiar to this type of pavement. A good example of this class of work is the Long Island Motor Drive, which is several miles in length. *Fig.* 3 illustrates this work during construction. The sub-grade was firstly shaped and rolled with a 10-ton roller. A layer of broken stone 2½ in. thick was then spread upon the sub-grade, and upon this broken stone a wire fabric reinforcement was laid over the entire width of the roadway with the separate sheets overlapping, as shown in the illustration (*Fig.* 3). A layer of broken stone was then spread upon the fabric so as to conform to the cross section of the roadway and give a pavement 5 in. in thickness after rolling. After the ballast was placed on the reinforcement it was thoroughly rolled and compacted with a 10-ton roller. Portland cement grout made with 1 part cement and 2 parts sand was mixed in a mechanical mixer and poured upon the surface of the rolled ballast until all the voids were filled and until the grout flushed to the surface after rolling. The grout was coloured with lamp black to slightly darken the finished pavement. After the grout had been poured and rolled a thin layer of pea stone was spread, grouted and the surface again rolled. The finished pavement was given a rough surface by brooming, so as to form very small ridges at right angles to the length of the roadway. Care was taken to com-

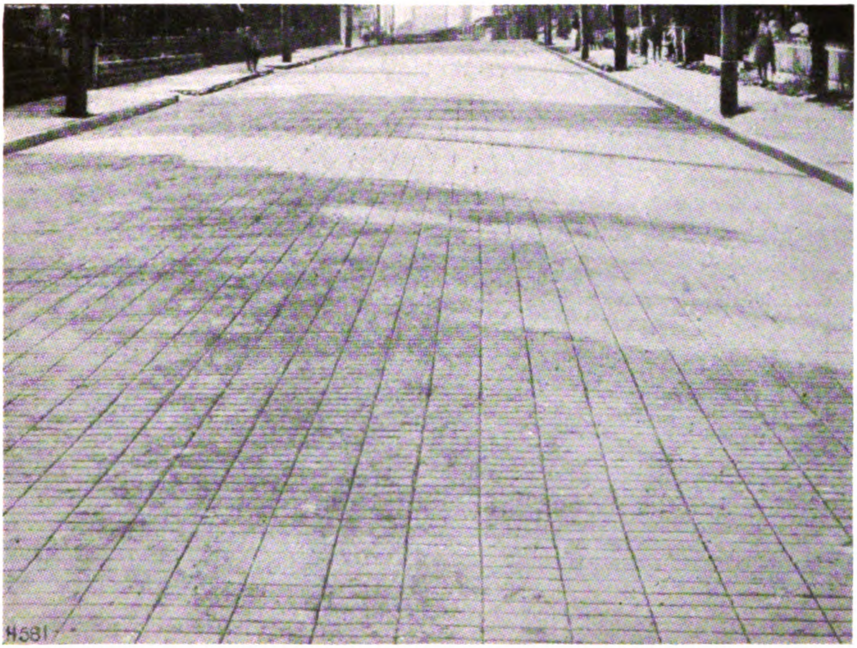


FIG. 5. PATENT CONCRETE PAVEMENT, KNOXVILLE, TENN.

plete all rolling after grouting each section before a sufficient period of time had elapsed to allow the cement to take its initial set. Automobiles were allowed on the finished pavement ten days after completion.

Another example of this type of road is that at Watertown, Mass., which is illustrated in *Fig.* 4. This was formed with a 6-in. thickness of rolled broken stone grouted with 1 part Portland cement and 2 parts of clean, sharp sand. The grout was mixed in a Hassam grout mixer. The surface of broken stone after the first grout was placed was covered with a pea grade of broken stone, and this finer stone in turn was covered with a grout of the proportion of 1 part of Portland cement and 1 part sand and rolled with a steam roller before the first grout had time to set.

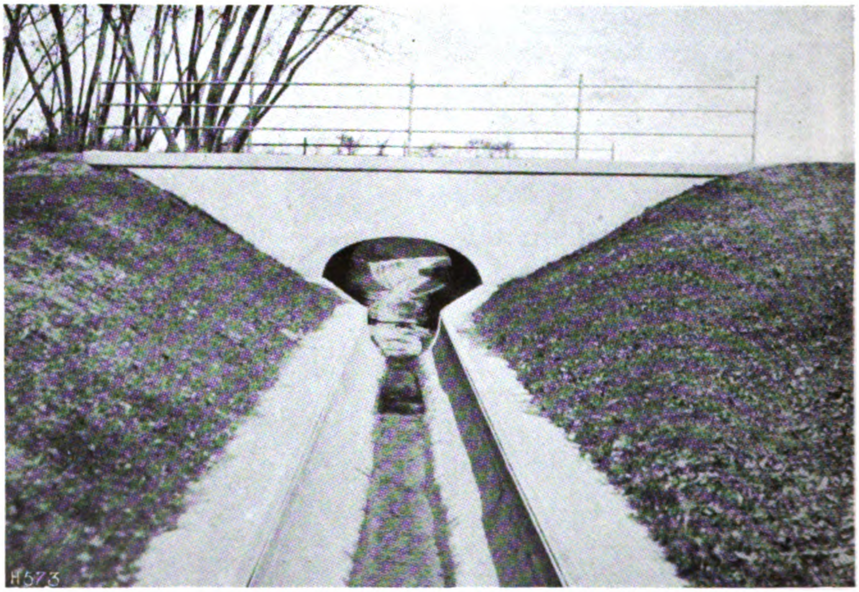


FIG. 6. CONCRETE BROOK LINING.

An example of another patented pavement is that illustrated in *Fig.* 5, showing a street in Knoxville, Tenn. This was formed with a foundation of concrete $5\frac{1}{4}$ in. thick and surface blocking $1\frac{3}{4}$ in. thick, making a total of 7 in., exclusive of the sub-grade, which was prepared with a layer of crushed stone 3 in. thick thoroughly consolidated. The concrete foundation was composed of 1 part of Portland cement, 3 parts sand, and 4 parts of crushed stone mixed by machinery and laid in sections with expansion joints.

After the concrete had been laid, and before it had time to set the granitoid blocking was laid. This was $1\frac{3}{4}$ in. thick and composed of 1 part Portland cement and 3 parts of clean crushed granite. This granite was carefully screened to remove all dust, and was of three sizes—viz., $\frac{1}{4}$ in., $\frac{1}{8}$ in. and $\frac{1}{16}$ in., there being 50 per cent. of the first, 30 per cent. of the second and 20 per cent. of the third size. After being laid this surfacing was worked to shapes approximately $4\frac{1}{2}$ in. by 9 in. with small grooved lines, this affording an excellent foothold for horses.

SEWERS, BROOK LININGS AND CONDUITS.

Large sewers are now frequently constructed entirely of concrete, and they have the advantage of being cheaper than brick, and in addition are more permanent and watertight and have a much smoother surface. They are of two kinds, large monolithic sewers moulded in position for diameters of more than 30 in. and concrete pipe sewers for any size ranging from 3 in. to 30 in. inside diameter. The former class are built of plain or reinforced concrete and for diameters of 3 ft. to 4 ft. the thickness required for good construction is usually sufficient without reinforcement, and they can be reckoned as strong as a brick sewer of the same diameter which is half again as thick. For large sewers reinforcement is generally advisable, and the saving in material will more than counter-balance the added cost of reinforcing. Concrete pipe sewers are made in lengths of 2 ft. or 3 ft. with tapering butt joint instead of the usual bell and spigot joint commonly used for stoneware and iron pipes, as this reduces the cost of manufacture and of the jointing in the trench. The thickness of concrete employed varies from 2 in. to 6 in., according to the diameter, and the usual proportions employed are 1 of Portland cement, 2 of clean sharp sand and 4 of crushed stone or gravel. A typical concrete brook lining executed in Newton, Mass., is illustrated in *Fig.* 6, this view being taken when the water level was very low. The concrete lining is curved to a radius of 18 in., inside diameter and the thickness at the upper surface of the concrete being 14 in. During extreme high water the cross section of the channel is not sufficient to carry the entire flow, so that once in a while the water overflows the normal cross section. Where the channel passes under the small culvert shown in the photograph it is slightly

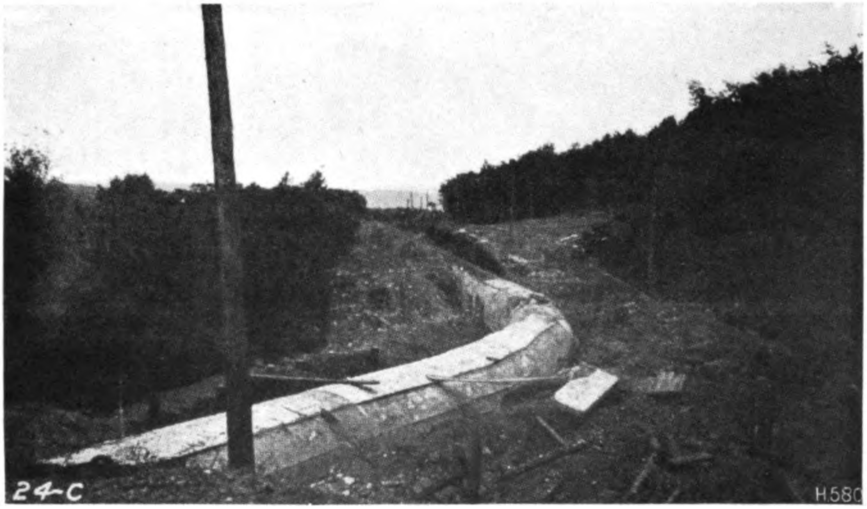


Fig. 7. Jersey City Conduit.

enlarged, and at this point it is reinforced with ½-in. rods spaced 10 in. apart. The culvert itself has a clear span of 8 ft. and a total depth of 5 ft. The thickness of the invert of the culvert is 6 in. at the middle, gradually enlarging towards the abutments, while the arch is 7 in. thick at the crown and increases gradually towards the abutments and is reinforced with ¼-in. rods 8 in. apart on centres. A typical conduit is that illustrated in *Fig.* 7, which was constructed for the Jersey City Water Supply Company. This conduit is approximately 8 ft. 6 in. inside diameter, and for a length of about 20,000 ft. is constructed of concrete. The thickness at the crown varies from 5 in. to 8 in., depending on the kind of material in which the pipe is placed and the depth of the filling over the pipe. The concrete generally was mixed with 1 part of Portland cement to 7 parts of sand and ballast, and it was all machine mixed.

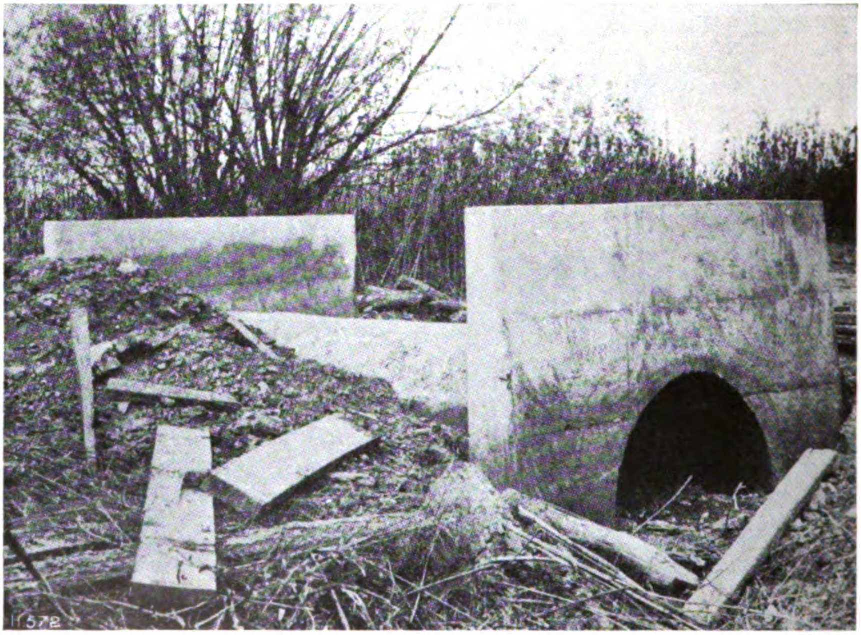


FIG. 8. CONCRETE ARCH CULVERT IN ILLINOIS.

CULVERTS.

Concrete has been extensively employed in this class of construction and its advantages are quite clearly demonstrated in the numerous examples which exist in highway and railway work. Culverts may be either square, rectangular, circular or arched in section. Rectangular types are easily built and conform very nearly to the cross section of the waterway, while arch culverts are usually better in appearance. Whatever the construction employed, it should be such as to prevent undermining—that is, to prevent the water from running along on the outside of the culvert and thus washing out the earth embankment. *Fig.* 8 illustrates an arch culvert built in Bureau County, Illinois, over a span of 5 ft. and it shows a typical example of the arch type. Plain concrete was employed, mixed in the proportions of 1 part Portland cement to 6 parts of sand and gravel.

BRIDGES.

We have on very many occasions given examples of bridges in reinforced concrete. Numerous bridges of all kinds have been constructed in this material on account of their permanence and freedom from maintenance charges, and in highway work a considerable amount of money has been expended in building concrete bridges to replace wooden and metal structures. They may be classified as flat bridges and arch bridges. The former type is suitable in level countries for short spans, generally not exceeding 30 ft. or 40 ft., and for locations where the foundation is soft material. Arches are especially economical in localities where the roads can be built considerably above the streams and where there is rock, or similar hard soil, which will afford a good foundation. Arch bridges include all those curved structures varying from simple culverts of 5 ft. or 10 ft. spans to the wonderful structures like the Walnut Lane bridge, described in previous issues, and which has an arch of 232 ft. clear span. The design of this bridge is remarkably successful, and it is doubtful if there is any structure equal to the arch bridge for showing the graceful lines that can be obtained with reinforced concrete, and the designer is not hampered by the small details which necessarily occur in many other classes of building work. *Fig.* 9 illustrates a highway bridge of 75 ft. clear span built in Concord, Massachusetts. The rise of the arch is 12 ft., or about $\frac{1}{8}$th of the span

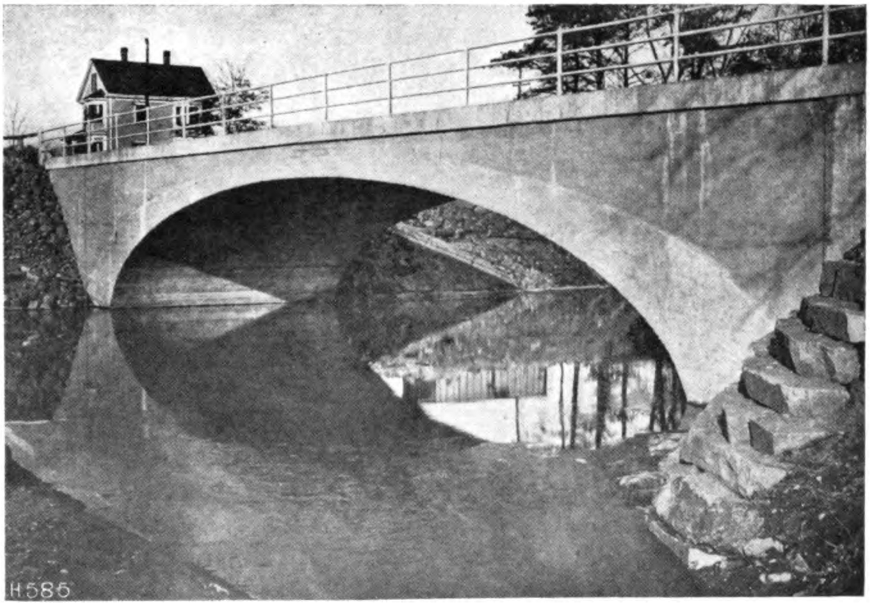
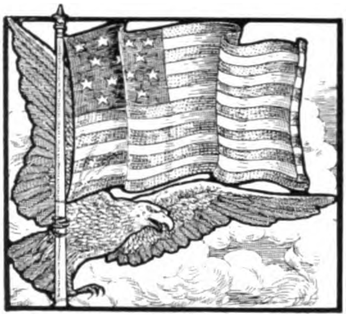


Fig. 9. Arch Bridge, with Span of 75 ft., in Concord, Mass., U.S.A.

length. At the crown the arch ring is 16 in. in thickness and increases towards the abutments as shown. The reinforcement in the arch ring consists of 1-in. longitudinal-twisted steel bars spaced 17 in. apart on centres and ¼-in. transverse-twisted steel bars spaced 24 in. apart on centres. The centres of the 1-in rods are 2¼ in. from the face of the concrete and these rods are in lengths of about 16 ft. lapped 40 in. at each splice. Reinforced side walls braced with counterforts serve to retain the earth filling. The steel in the side walls consists of ⅝-in. horizontal rods spaced 12 in. apart on centres near the bottom and ½-in. rods spaced 24 in. apart near the top of the wall. In the coping there are also two ¼-in. longitudinal rods and the counterforts are provided with tie rods. Four hundred and fifty-eight cubic yards of Portland cement concrete were used in this bridge.

There are many other uses for which concrete and reinforced concrete can be employed in highway construction, and, in fact, there are so many types that it would be impossible to give a satisfactory description of them all in this article. Examples have been illustrated from time to time in this journal and they include retaining walls, fence posts, lamp posts, hitching posts, fountains and other highway appurtenances.



REPORT OF COMMITTEE ON REINFORCED CONCRETE.

ISSUED BY THE AMERICAN NATIONAL ASSOCIATION OF CEMENT USERS.

The first part of this Report dealing with the general aspects of the subject appeared in our July number. In this issue we give the remainder of the Report, embodying some of the more important details and conclusions.—ED.

PART II.

STANDARD NOTATION.

68. The following notation is recommended by the Joint Committee :

M = moment of resistance, or bending moment in general, in inch pounds.
A = steel area in square inches.
f_s = tensile unit stress in steel.
f_c = compressive unit stress in concrete.
b = breadth of beam (in a **T**-beam, breadth of flange) in inches.
b' = breadth of web or stem in a **T**-beam in inches.
d = depth of beam from compressive surface to centre of steel in inches.
t = thickness of flange in inches.
d = distance between centre of compression and centre of steel in inches.
k = ratio of depth of neutral-axis to effective depth, d.
V = total shear in pounds.
v = shearing unit stress in pounds per square inch.
u = bond stress per unit area of bar.
o = circumference or perimeter of bar in inches.
Σo = sum of the perimeters of all bars in inches.
s = distance apart of the stirrups.

RECTANGULAR BEAMS.

69. In a rectangular beam neither the allowable working compressive stress in the concrete nor the allowable tension in the steel should be exceeded. These stresses in practice may be determined by the following formulæ :

$$f_s=\frac{M}{\cdot 87\,Ad} \qquad (1)$$

$$f_c=\frac{2M}{jkbd^2} \qquad (2)$$

For 0·8 per cent. steel, which gives the stresses already suggested for 2,000 pound concrete, $j=0{\cdot}88$, and $k=0{\cdot}38$, so that the value of f_c becomes approximately $\frac{6M}{bd^2}$.

70. For a design based on working stresses recommended in paragraphs 60, 66 and 67, *i.e.*, compression in concrete 650 pounds per square inch, tension in steel 16,000 pounds per square inch and ratio of elasticity of 15, the depth of the beam is

$$d=\frac{1}{10}\sqrt{\frac{M}{b}} \qquad (3)$$

In order to have the specified tension and compression so that the above formula will apply, the percentage of steel must be 0·8 per cent. The area of cross section of tensile steel reinforcement is therefore

$$A=0.008bd \qquad (4)$$

In using these formulæ, the maximum bending moment, M, is computed in inch-pounds, the breadth b is assumed and the depth to steel, d, is found from the formula.

The full depth is obtained by adding to d a thickness of concrete required to imbed and protect the steel. The area of steel is then obtained from formula (4). Shear and bond are considered in succeeding paragraphs.

T-BEAMS.

71. Where adequate bond between slab and web of beam is provided, the slab may be considered as an integral part of the beam, and its effective width may be determined by the following rules:

(a) It shall not exceed one-fourth of the span length of the beam;

(b) Its overhanging width on either side of the web shall not exceed four times the thickness of the slab.

72. Following the above requirements and where ample provision has been made for shear, the formulæ just given for rectangular beams may be applied without material error so long as the depth, d, is not greater than 5 times the thickness of the slab.*

73. In using the rectangular beam formulæ the width of the slab as above specified is taken as the breadth of beam, b, in computing compression, but in the formulæ for shear and bond the width of the stem or web is used.

74. The area of steel may be obtained (when the depth of beam, d, does not exceed 5 times the thickness of the slab) by the formula

$$A = \frac{M}{{\cdot}87 f_s d} \qquad (5)$$

For 16,000 pound stress in steel this formula becomes

$$A = \frac{M}{14{,}000\, d} \qquad (6)$$

75. The width of the stem or web of the **T** is governed by the proper embedding of the rods and the area required to resist diagonal tension, as indicated in paragraphs which follow. Web reinforcement is considered in paragraphs 86 to 95.

FLOOR SLABS.

76. Floor slabs should be designed and reinforced as continuous over the supports. If the length of the slab exceeds 1·5 times its width the entire load should be carried by transverse reinforcement. Square slabs may well be reinforced in both directions using one-half the computed reinforcement in each direction.

77. The loads carried to beams by slabs which are reinforced in two directions will not be uniformly distributed to the supporting beam, but may be assumed to vary in accordance with the ordinates of a triangle. The moments in the beams should be calculated accordingly.

CONTINUOUS BEAMS AND SLABS.

78. In computing the positive and negative moments in beams and slabs continuous over several supports, due to uniformly distributed loads, the following rules are recommended by the Joint Committee:

(a) That for floor slabs the bending moments at centre and at support be taken at $\frac{wl^2}{12}$ for both dead and live loads, where "w" represents the load per lineal foot and "l" the span length.†

(b) That for beams the bending moment at centre and at support for interior spans be taken at $\frac{wl^2}{12}$, and for end spans it be taken at $\frac{wl^2}{10}$ for centre and adjoining support, for both dead and live loads.†

79. In the case of beams and slabs continuous for two spans only, or of spans of unusual length, more exact calculations should be made. Special consideration is also required in the case of concentrated loads.

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* Beyond these limits the more exact formulæ given in the report of the Joint Committee should be adopted.

† A still more conservative plan is to use $\frac{wl^2}{10}$ at the middle of all spans.

BONDING STRENGTH AND SPACING OF BARS.

80. In direct pull or direct compression a bar must be embedded a length sufficient to give a working strength in bond equivalent to the working strength of the steel in tension or compression. For 2,000 pounds concrete, in which 80 pounds per square inch is permitted in bond, and a working strength of 16,000 pounds per square inch in the steel, plain round bars thus require an embedded length of fifty diameters.

81. The bond stress in the horizontal bars in a beam may be represented by the formula

$$u=\frac{V}{jd\Sigma o} \qquad (7)$$

82. With the unit bond of 80 pounds per square inch (assuming $jd=\frac{7}{8}$ d), the total circumference of tension rods at any section of the beam should be at last

$$\Sigma o=\frac{V}{70\ d} \qquad (8)$$

83. For **T**-beams b′ is substituted for b, and jd may be taken as approximately the distance from centre of slab to steel.

84. Where high bond resistance is required, the deformed bar is a suitable means of supplying the necessary strength. Adequate bond strength throughout the length of a bar is preferable to end anchorage, but such anchorage may properly be used in special cases. Anchorage furnished by short bends at a right angle is less effective than hooks consisting of turns through 180 deg.

85. The lateral spacing of bars should not be less than two and one-half diameters, centre to centre, nor should the distance from the side of the beam to the centre of the nearest bar be less than two diameters. The clear spacing between two layers of bars should be not less than ½ in.

SHEAR AND DIAGONAL TENSION.

86. Calculations for web resistance shall be made on the basis of maximum shearing stress as determined by the formulas hereinafter given. When the maximum shearing stresses exceed the value allowed for the concrete alone, web reinforcement must be provided to carry the diagonal tensile stresses involved. This web reinforcement may consist of bent bars, or inclined or vertical members attached to or looped about the horizontal reinforcement. When inclined members are used, the connection to the horizontal reinforcement shall be such as to ensure against slip.

87. Experiments bearing on the design of details of web reinforcement are not yet complete enough to allow more than general and tentative recommendations to be made. It is well established, however, that a very moderate amount of reinforcement, such as is furnished by a few bars bent up at small inclination, increases the strength of a beam against failure by diagonal tension to a considerable degree; and that a sufficient amount of web reinforcement can readily be provided to increase the shearing resistance to a value from three or more times that found when the bars are all horizontal and no web reinforcement is used.

88. The Joint Committee recommend the following allowable values for maximum shearing stresses for concrete whose crushing strength is 2,000 pounds at twenty-eight days:

(a) For rectangular beams with horizontal bars only, web reinforcement is necessary when $\frac{V}{bjd}$ is greater than 40, or (assuming distance between centres of tension and compression to be $\frac{7}{8}$ d) when $\frac{V}{bd}$ is greater than 35.

(b) For rectangular beams in which a part of the horizontal reinforcement is used in the form of bent-up bars arranged with due respect to shearing stresses, a higher value may be allowed, but not to exceed 60 pounds per square inch. In this case (assuming $jd=\frac{7}{8}$ d) stirrups will be required when $\frac{V}{bd}$ is greater than 52.

(c) In any case, no matter how thoroughly reinforced for diagonal tension, the total shear should not exceed 120 pounds per square inch, that is (assuming $jd=\frac{7}{8}$ d) bd must never be less than $\frac{V}{105}$.

89. For **T**-beams the same rules apply, except that only the web of the beam is effective; hence, b′ must be substituted for b.

90. In the calculation of web reinforcement to provide a strength of 120 pounds per square inch, the concrete may be counted upon as carrying one-third of the shear, or for 2,000 pound concrete 40 pounds per square inch. The remainder may be provided for by means of metal reinforcement consisting of bent bars or stirrups, but preferably both. The area of a stirrup, acting in tension, must be proportioned to the force equal to the whole horizontal shear produced between the two adjacent stirrups less the amount to be carried by the concrete. This total horizontal shear may be found by multiplying the distance between stirrups by the average horizontal unit shear, which is equal to the vertical unit shear, and is represented by the expression $\frac{V}{jd}$.

91. In accordance with this method the stress in a vertical stirrup will be equal to $\frac{Vs}{jd}$ and in a stirrup or bent rod at 45 deg. it will equal $0{\cdot}7\,\frac{Vs}{jd}$, in which s = horizontal spacing, that is, the distance apart, of stirrups or bent rods.

92. In these formulas V is taken as the proportion of total shear assumed as carried by the reinforcement.

93. The longitudinal spacing of stirrups shall not exceed three-fourths the depth of the beam in the portion of the beam where the shearing stresses exceed the allowable shearing value of the concrete.

94. It is important that adequate bond strength be provided to fully develop the assumed strength of all shear reinforcement.

95. Inasmuch as small deformation in the horizontal reinforcement tends to prevent the formation of diagonal cracks, a beam will be strengthened against diagonal tension failure by so arranging the horizontal reinforcement that the unit stresses at points of large shear shall be relatively low.

COLUMNS.

96. It is recommended that the ratio of unsupported length of column to its least width be limited to fifteen.

97. The effective area of the column shall be taken as the area within the protective covering, as defined in paragraph 3. Or in the case of hooped columns or columns reinforced with structural shapes it shall be taken as the area within the hooping or structural shapes.

98. Columns may be reinforced by means of longitudinal bars, by bands or hoops, by bands or hoops together with longitudinal bars or by means of structural forms which in themselves are sufficiently rigid to act as columns. The general effect of bands or hoops is greatly to increase the "toughness" of the column and its ultimate strength, but hooping has little effect upon its behaviour within the limit of elasticity. It thus renders the concrete a safer and more reliable material and should permit the use of a somewhat higher working stress. The beneficial effects of "toughening" are inadequately provided by a moderate amount of hooping, a larger amount serving mainly to increase the ultimate strength and the possible deformation before ultimate failure.

99. The following recommendations are made for the relative working stresses in the concrete for the several types of columns:

(a) Columns with longitudinal reinforcement only, the unit stress recommended in paragraph 58.

(b) Columns with reinforcement of bands or hoops, as specified below, stresses 20 per cent. higher than given for *a*.

(c) Columns reinforced with not less than 1 per cent. and not more than 4 per cent. of longitudinal bars and with bands or hoops, stresses 45 per cent. higher than given for *a*.

(d) Columns reinforced with structural steel column units which thoroughly encase the concrete core, stresses 45 per cent. higher than given for *a*.

100. In all cases, in addition to the stress borne by the concrete given above, longitudinal reinforcement is assumed to carry its proportion of stress in accordance with the ratio of its elasticity to concrete. For example, with a working stress in concrete of 450 pounds per square inch, the longitudinal reinforcement may be assumed to carry 15 by 450 = 6,750 pounds per square inch.

101. The hoops or bands are not to be counted upon directly as adding to the strength of the column.

102. Bars composing longitudinal reinforcement shall be straight and shall have sufficient lateral support to be securely held in place until the concrete is set.

103. Where bands or hoops are used, the total amount of such reinforcement shall be not less than 1 per cent. of the volume of the column enclosed. The clear spacing of such bands or hoops shall be not greater than one-fourth the diameter of the enclosed column. Adequate means must be provided to hold bands or hoops in place so as to form a column, the core of which shall be straight and well centred.

104. Bending stresses due to eccentric loads must be provided for by increasing the section until the maximum stress does not exceed the values above specified.

SPLICING OF BARS.

105. Wherever in tension reinforcement it is necessary to splice the reinforcing bars, the length of lap shall be determined on the basis of the safe bond stress and the stress in the bar at the point of splice; or a connection shall be made between the bars of sufficient strength to carry the stress. Splices at points of maximum stress should be avoided. In columns large bars should be properly butted and spliced; small bars may be treated as indicated for tension reinforcement or their stress may be taken off by being embedded in large masses of concrete. At foundations, bearing plates should be provided for large bars or structural forms.

REINFORCING FOR SHRINKAGE AND TEMPERATURE STRESSES.

106. Where large areas of concrete are exposed to atmospheric conditions, the changes of form due to shrinkage (resulting from hardening) and to action of temperature are such that large cracks will occur in the mass, unless precautions are taken to so distribute the stresses as either to prevent the cracks altogether or to render them very small. The size of the cracks will be directly proportional to the diameter of the reinforcing bars and inversely proportional to the percentage of reinforcement and also to its bond resistance per unit of surface area. To be most effective therefore reinforcement should be placed near the exposed surface and well distributed, and a form in reinforcement used which will develop a high bond resistance.

Submitted by the Committee,

Sanford E. Thompson, *Chairman,*
Frank P. McKibben,
Charles S. Spofford,
Arthur N. Talbot,
Henry C. Turner.

APPENDIX.

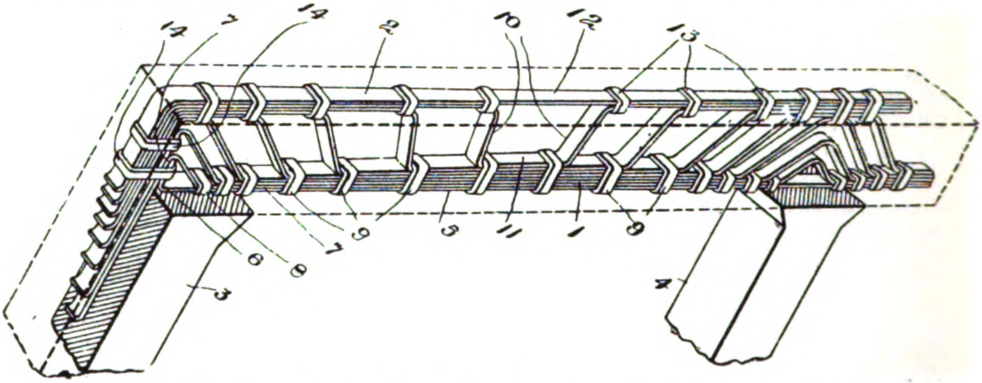
Tests by New York Board of Water Supply of 1 : 3 Mortar made with Sands of Different Mechanical Analysis.

Percentages Passing Sieves.				Tensile Test.		Compression Test.	
No. 4	No. 8	No. 50	No. 100	7 days	90 days	7 days	90 days
100	70	12	5	213	613	2690	5640
100	86	21	6	263	412	1915	4660
100	99	26	2	177	325	905	2170
100	97	28	6	178	282	1070	1500
100	94	44	12	139	228	905	1130
100	100	52	14	122	170	275	810
100	100	94	48	80	149	330	490

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. These particulars have been prepared for this Journal by Mr. A. W. Farnsworth, of Strand Chambers, Derby.—ED.

A Simple Reinforcement. *No. 8737/09. S. Burrowes. Accepted, Feb. 10/10.*—The invention relates to an ingenious arrangement of the steel bars so that, although theoretical accuracy is not neglected, the practical execution of the work is simplified. It is proposed to form the reinforcement of flat steel, which may be all one stock size. The increased sectional area required at any point is obtained by increasing the number of strips and securing them together by means of clips bent round them. The diagonal shear members are made by bending some of the strips upwards as usual, but, as they may be extended and clipped to the steel in compression or on the other side of the member, there are no loose ends to be disturbed when the concrete is placed in position. It is claimed that the reinforcement may be easily and cheaply made up from steel flats of market sizes, that transport is rendered easier, and the actual work on the building may be carried out without special machinery or tools.



The Manufacture of Stock Reinforced Concrete Beams. *No. 10296/09. A. N. Tucker. Accepted, May 2/10.*—In the specification the inventor explains that certain defects usually occur in beams which are made to specified sizes and afterwards used to form floors or roofs. The leading objection he raises are, the liability of the steel to move when attached to a core and the use of very thin webs which necessitate an exceedingly small aggregate. In order to overcome these disadvantages the beam shown on the illustration is proposed, as it consists of two substantial side webs to hold the reinforcement connected by a comparatively thin upper slab. The beams are made with their upper faces downwards, which facilitates the introduction of the steel bars where required. When a ceiling is desired expanded metal, or any other suitable lathing, is laid across the under side and attached to the rods during the process of manufacture.

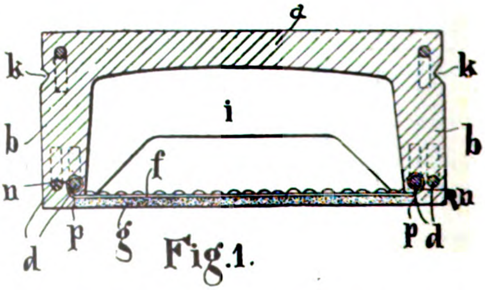


Fig. 1.

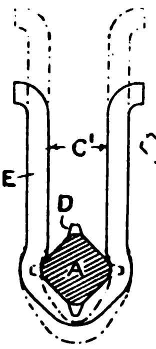


Fig.4

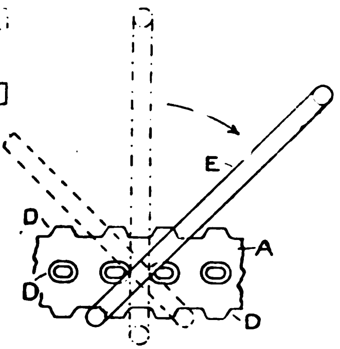


Fig.5.

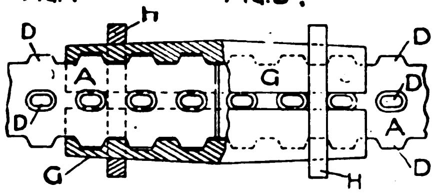
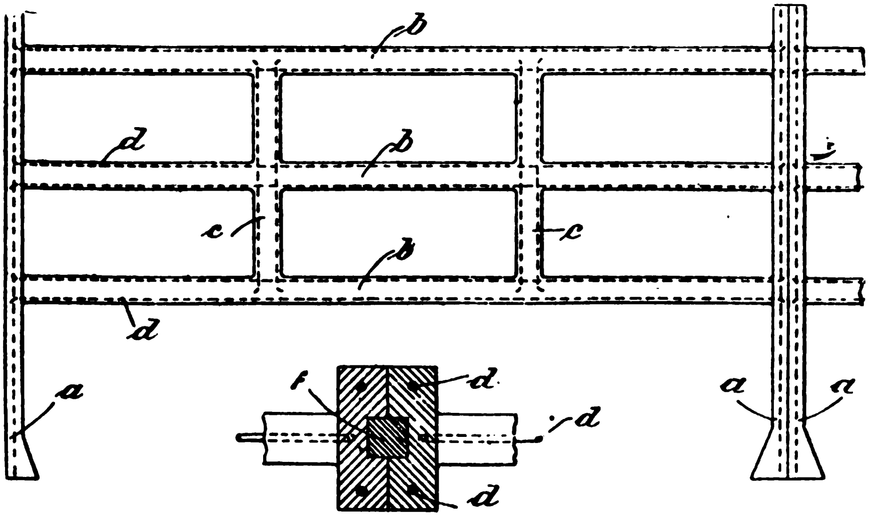


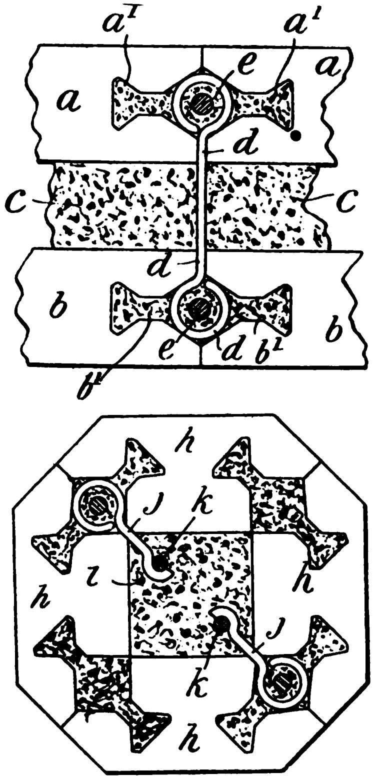
Fig. 12

A New Bar. *No. 17122/09. Jeffree and McGregor. Accepted May 26/10.*—Several forms of a new corrugated bar are introduced by the inventors, who aim at providing a simple but substantial mechanical bond between the bars and the stirrups. The chief feature of the invention is the formation of a series of studs or projections on the bars to prevent the stirrups slipping. The proposed attachments are generally U-shaped and are wide enough to pass over the bars between the studs. As shear members are often placed at 45° or 90° to the main bars the projections are arranged accordingly: in *Fig.* 5 the members are shown in both positions In addition to the foregoing the inventors also describe a coupling for the end of the principal bars, which is formed to clip over the projections, and is similar to a box coupling for shafting. That is, the coupling is split longitudinally, and is slightly tapered towards the ends on the outside, so that it can be wedged together by the rings (H), which are driven over it.

A Reinforced Concrete Fence. *No. 23400/09. H. M. Rootham. Accepted, Feb. 17/10.*—The fence shown in the illustration is cast in sections or hurdles, with the steel embedded in them. A series of the sections can therefore be erected end to end, to form a continuous fence. The outer side of both end posts of each section are grooved along their full length. Consequently, when erected, a cavity is formed between each pair of end posts, which abutt against each other. This is filled with cement grout, and forms a solid key between the sections.



It is pointed out that a fence of this description may be readily erected with little labour.



The Construction of Hollow Stonework with Concrete Filling. *No. 13991/09. E. W. Brock and the Bath Stone Firms, Ltd. Accepted, March 24/10.*—In the erection of concrete walls or columns with stone facings it is obvious that the stonework would form the shuttering, provided suitable means were available to hold it in position. The invention consists of a special arrangement to obtain this result. In the vertical joints of the stonework are V notches, which come together, and are filled with concrete to form a key. Down the centre of each pair of notches passes a vertical steel rod. At intervals opposite rods are connected together by distance pieces threaded over them. Slight chases are cut in the stone to permit the insertion of the distance pieces. It will be readily understood that even without the concrete the steel rods would be sufficient to hold the facing in position, and when the process of filling is carried out they still remain and constitute excellent ties.

Another Proposed Reinforcement. *No. 4579/10. W. J. Swain. Accepted, March 10/10.*—The economical and practical disposition of the steel in reinforced-concrete construction receives constant attention from inventors who seek to combine simplicity with strength. The object of this invention is to avoid the use of all special bars and clips, and yet to maintain sufficient rigidity to avoid any displacement of the reinforcement during erection. It is also intended to do away with the practice of distorting the main bars, which the inventor points out is liable to set up high initial stresses in the steel. Taking the steel in a reinforced concrete beam as an example, it is therefore proposed that it should consist of upper and lower members (2 and 3), which are ordinary round bars, connected by diagonal bracing formed into elongated loops, according to the design in *Fig.* 3. It will be easily seen that the loops may be conveniently slipped into position, and there fastened by small lashings or clips (4). Various modifications are described in the specification, and it is claimed that the arrangement is particularly suitable for structures liable to shocks or settlement.

Fig.1

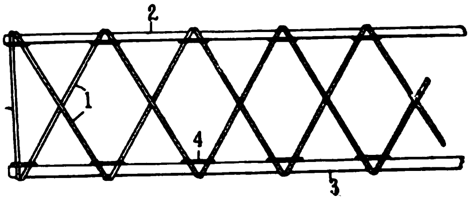
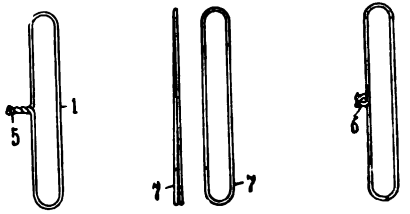
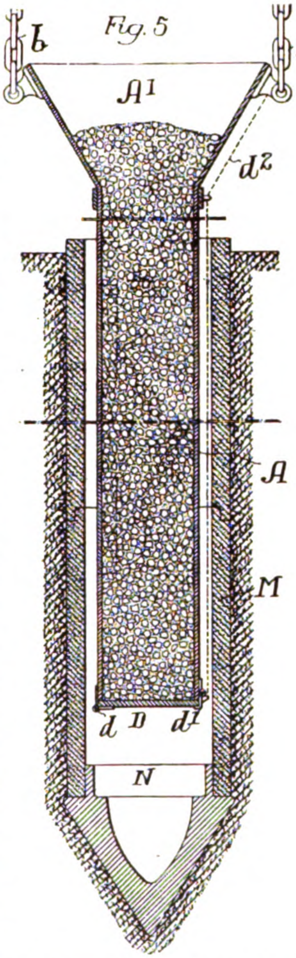
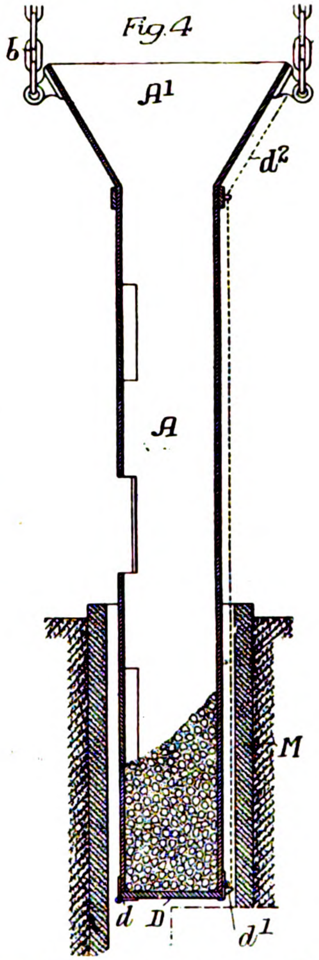


Fig.3

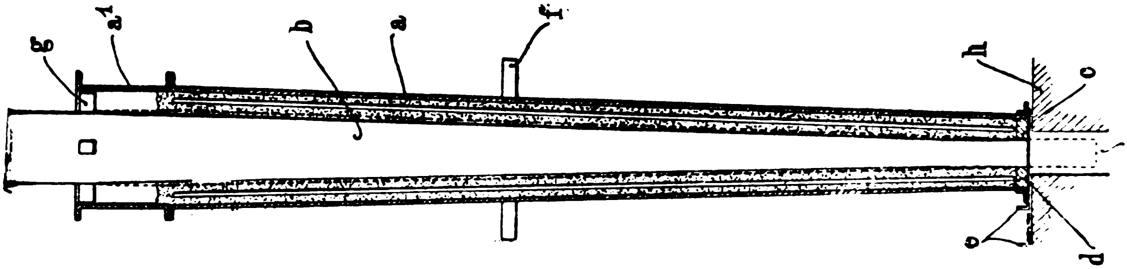


A Device for Filling Holes with Concrete. *No. 30317/09. L. E. Welch. Accepted, May 12/10.*—In introducing the invention, which is particularly adapted for filling in hollow concrete piles, the inventor refers to the well-known objections to dropping concrete from any height and to the tedious alternative of using a trip bucket, which is filled, lowered into the hole and emptied. He therefore proposes that the concrete filling should be lowered into position *en masse*, or at least in large quantities by means of the special device which is the subject of the invention. This consists of a long tube or box which may be lowered endways into the hole by means of a crane. At intervals up the side of the tube are doors so that as it sinks down concrete may be gradually filled in at the ground level. The lower end of the tube is temporarily closed by means of a door of pottery or some similar fragile substance. This is held in position by trip catches as the tube descends. The catches are released when the tube is low enough by means of a cord (d^2) which is led up to the ground surface. The door (D) breaks from the shock and the concrete falls out whilst the tube is gradually hoisted clear of the hole. The funnel top to the tube is provided to hold an extra amount of concrete to allow for the difference between the sectional area of the tube and the hole. It is pointed out that the device acts as a gauge and ensures a hole of proper diameter.





A Mould for Piles. *No. 27997/09. T. Frey. Accepted, Feb. 24/10.*—This is a mould intended for use in the manufacture of hollow tapered concrete columns. It consists of a shell (a), which is split longitudinally for convenience in inserting the reinforcement, or for the removal of the finished product. The core (b) is also tapered, and is kept in position at the top by projections (g) formed on the inside of the shell. The smaller end of the mould is closed by a solid base (d), which has a hole in the centre large enough to permit the passage of the small end of the core: the opening may be temporarily closed by a slide (e). At the commencement of the process the slide is closed, and the end of the core rests on it. The concrete is poured in from the top to fill the space between the core and the shell. The sides of the shell have trunnions, so that the whole may be picked up by a crane. On the completion of the concreting the slide is withdrawn, so that the core may drop, and thus consolidate the concrete by pressing it against the sides of the mould. If the whole arrangement is slightly raised and dropped suddenly several times it is clear that the core will continue to wedge itself tighter into the concrete. When the concrete is set, the mould is raised and reversed on the trunnions, so that the core will fall out.



A New System of Floor Construction. *No. 4807/09. Leslie & Co. and H. Kempton Dyson. Accepted, Feb. 24/10.*—The object of the invention is to avoid the use of main or cross beams where the columns which support the floor can be placed reasonably close together. By reference to *Fig.* 1 it will be understood that the theory of floor construction has in this instance been considered from a fresh aspect. The position of the columns is indicated at A, and for the purpose of calculation the floor is divided into a series of imaginary rectangles (B and C). The rectangles B are symmetrical about the axes of the columns, and are regarded as cantilevers, whilst the intervening rectangles C are obviously floor slabs, supported on all four sides. On account of the increase in the stresses the thickness of the portions above the columns is gradually increased towards the points of support, as shown in *Fig.* 13. A detailed account of the best positions for the steel, and the manner in which it should be arranged, is described in the specification.

Fig. 1

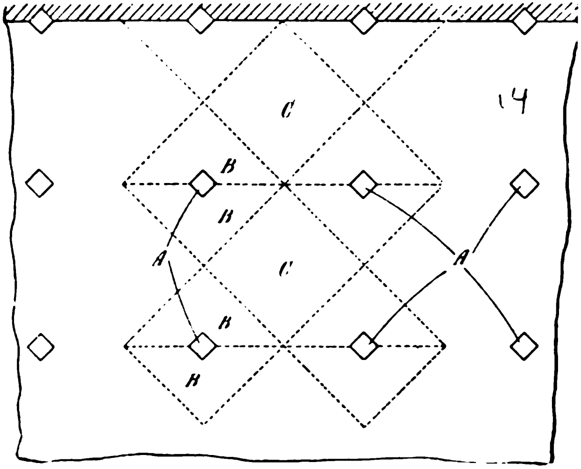
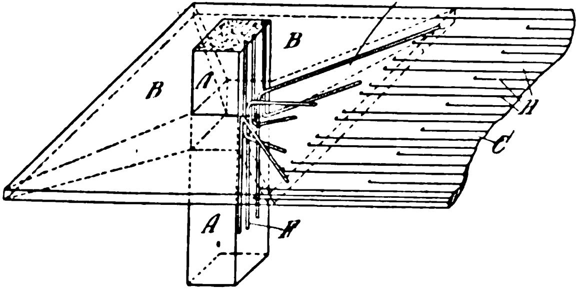
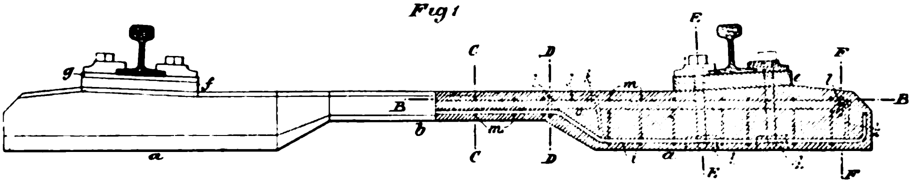


Fig. 13.

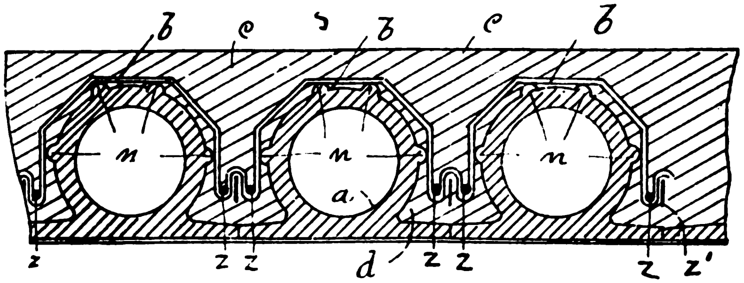


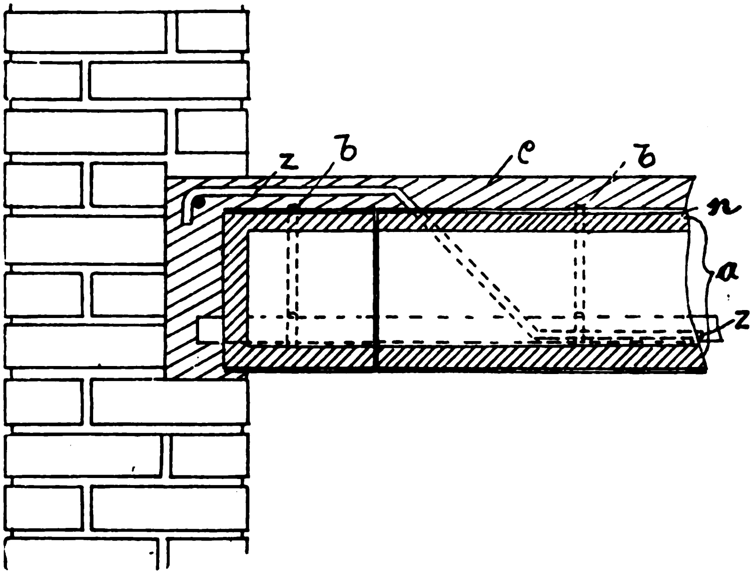
Improved Concrete Sleepers. *No. 13022/09. H. C. Werner. Accepted, March 24/10.*—The design of sleepers in reinforced concrete has received considerable attention, as the severe stresses induced call for special attention. Attempts have been made by the liberal use of steel to resist the bending moment set up in the centre of such sleepers, when made in the conventional rectangular form. On reference to the illustration it will be at once seen that the inventor's sleeper does not bear on the ground at the centre, so that the bending tendency is avoided. It consists of two large concrete bases, one under each rail chair, connected by a strut, which is bent upwards to avoid contact with the road ballast, but is strong enough to resist all lateral stresses. The ends of the sleeper transmit the whole of the load, and are adequately reinforced to resist bursting. It is stated that if the sleeper is subjected to the application of the usual load in a newly laid road it will sink uniformly to a permanent position, without any tendency to rebound.

Fig 1



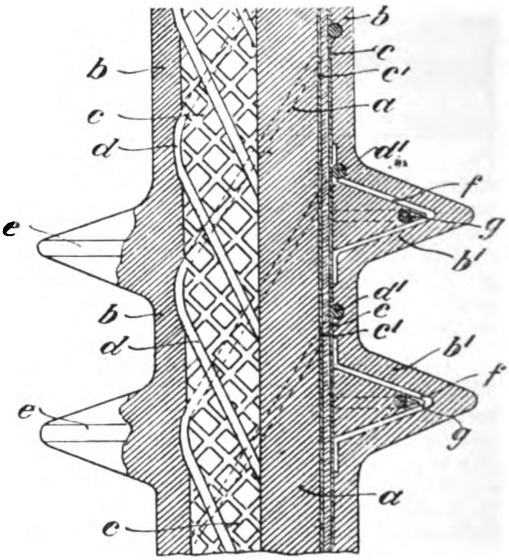
An Improvement in the Construction of Hollow Floors. *No. 22936/09. Hohl-Ton-Eisenbeton Vertriebgesellschaft & Ruppert. Accepted, May 12/10.*—Already there are many types of hollow floors constructed of terra-cotta or similar blocks embedded in concrete. It is generally essential to place the steel reinforcement low down between the blocks where it may be liable to displacement during the concreting. The object of the invention consists in a special arrangement of stirrups to ensure the accurate disposition of the bars (zz). The stirrups, which are made of flat bar steel, pass over the tops of the blocks and dip down





between them to pick up the reinforcement; at this point they are joggled in order to maintain the bars at the correct distance apart. It will be noticed that ribs are formed on the outside of the hollow blocks. These raise the stirrups slightly so that they are entirely surrounded by concrete. It is claimed that the method combines the certainty of adhesion between the steel and the concrete with the required rigidity during erection.

Reinforced Concrete Screw Piles. *No. 10041/09. G. C. Vernon-Inkpen. Accepted, May 26/10.*—A variety of screw piles suitable for foundations of different natures are described in the specification. Although the forms of the piles are varied according to possible requirements, each design retains the principles of construction which form the subject of the invention. The steel cores are made of expanded steel or similar material (c) around which are wound continuous spirals of round steel bars (d). Vee brackets (f) to support the screw threads are attached at intervals and are connected together at the apices by another round bar (g) wound spirally. The various portions of the reinforcement are lashed together at intervals with steel wire. The claim is made for the arrangement of the steel which is intended to resist the torsion when sinking as well as to resist the tensile stress induced when the pile is in position.



REINFORCED CONCRETE LINING OF THE STEEL CHIMNEY STACKS AT RINGSEND GENERATING STATION, DUBLIN.

By P. S. SHEARDOWN, M.I.E.E., M.I.C.E.I.

(Electrical Engineer, Dublin United Tramways Company.)

The question of applying reinforced concrete to chimney construction has been dealt with at length in these columns.

The present article by Mr. P. S. Sheardown, M.I.E.E., M.I.C.E. (Ireland), however, relates to the problem of lining steel chimney stacks with reinforced concrete, which deserves close attention. We believe that the data given below, if read with some of our previous references to the subject generally, should be of considerable use to factory owners and their technical advisers.—ED.

REINFORCED CONCRETE FOR CHIMNEY LINING.

THE two chimneys at the Power Station at Ringsend, Dublin, were built in 1898; they are each 200 ft. above the brick bases, which are themselves 25 ft. high. The stacks above the bases are constructed of steel plates, the bottom 50 ft. being $\frac{3}{8}$ in. thick, the next 50 ft. are $\frac{5}{16}$ in. thickness, and for the top 100 ft. the plates are $\frac{1}{4}$ in. thick. They are lined to the top with fire brick, but as it was anticipated owing to the height of the chimney that trouble might be experienced through unequal expansion, if the brick work was set hard against the steel work, the linings were built independently, leaving a space of about 3 in. between the brick work and the steel shell.

The chimneys for some years appeared to be doing well, but as a case was brought to the writer's notice of a small works in Dublin where a steel chimney had to be replaced after a life of four or five years, a second one at the same works only giving a similar life to the first, it was considered desirable to make a careful examination of the tramway company's chimneys, more particularly in view of the fact that an inspection of the small chimneys referred to showed that the corrosion of the plates seemed to take place from the inside. As they were not provided with brick linings, like the tramway chimneys, corrosion from the inside was not anticipated in these latter. However, when a careful inspection came to be made it was found that in the case of the east chimney the plates had rusted away until perforation had occurred in several of the plates, corrosion taking place entirely from the inside. The exterior of the plates was well protected by paint, and no deterioration had been noticed at the previous painting of the chimneys. The plates in each chimney were carefully tested by drilling holes and callipering for thickness, when it was found that in many parts of both chimneys the plates had rusted away to an extent that materially reduced their strength, and it was obvious that some method of strengthening them and preventing further corrosion would have to be taken in hand. After carefully considering various methods suggested, it was decided to reinforce both the chimneys with a reinforced concrete lining. In the case of the east chimney, which has a diameter at the base of 10 ft. 8 in., it was decided to build a reinforced concrete lining 10 in. thick inside the existing brick work, reducing the diameter of the chimney to 9 ft. It was decided to remove only the top 20 ft. of the original brick lining, so as to get a bond for this length between the reinforced concrete lining and the steel work, in order to prevent deleterious gases or damp from getting between the brick work and the steel shell. It was intended also to fill in the space between the steel shell and the original brick lining with a liquid cement grouting, but this was not found to be practicable as explained later on.

The lining was designed by the Weber Chimney Construction Company, of U.S.A., and the work was carried out by their Licensees, Messrs. J. Jarvis and Sons, Ltd., of Hackney Road, London, N.E. The concrete mixture consisted of three parts of fine sand to one part of cement; the vertical reinforcements consisted of steel **T** bars $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in. by $\frac{3}{16}$ in., and the horizontal reinforcements of $\frac{5}{8}$-in. round steel. These horizontal rings were put in 18 in. apart, the number of vertical steel bars being 300 at the base of the chimney, the number being gradually diminished until at the top there were only twelve.

The lining is designed to withstand a wind pressure of 56 pounds per sq. ft. (or a velocity of 112 miles per hour) without help from the original steel shell.

The lining of the first chimney was completed in January, 1909, and has been repeatedly inspected from the inside since being put to work, and so far the lining seems to stand the heat and other stresses splendidly, as, beyond some small hair cracks which are always noticeable in this class of construction, the lining is in excellent condition.

A couple of months after being put to work it was noticed that the rivets had pulled out of a horizontal section of the steel chimney about halfway up, and that the top half had risen about three-quarters of an inch. This was caused by the greater expansion of the reinforced concrete lining due to its higher temperature compared with the steel shell. The steel shell is, therefore, now in practically two pieces, the overlapping where the rivets have pulled out acting as an expansion joint, the reinforced concrete lining, therefore, taking the whole of the wind pressure.

When the proposed grouting between the steel shell and the original brickwork lining was put in hand, it was found that, owing to the quantity of soot that had fallen down between the brick-work and lining, a satisfactory job could not be made, and in consequence of this the west chimney, in which the plates were not so much corroded, was differently treated, the whole of the original brick lining being removed and the reinforced concrete lining filled in hard against the steel work, which enabled the company to have a chimney with an inside diameter of 10 ft. in place of only 9 ft., as is the case with the east chimney, besides allowing a much greater thickness of concrete in the lower part of the chimney stack.

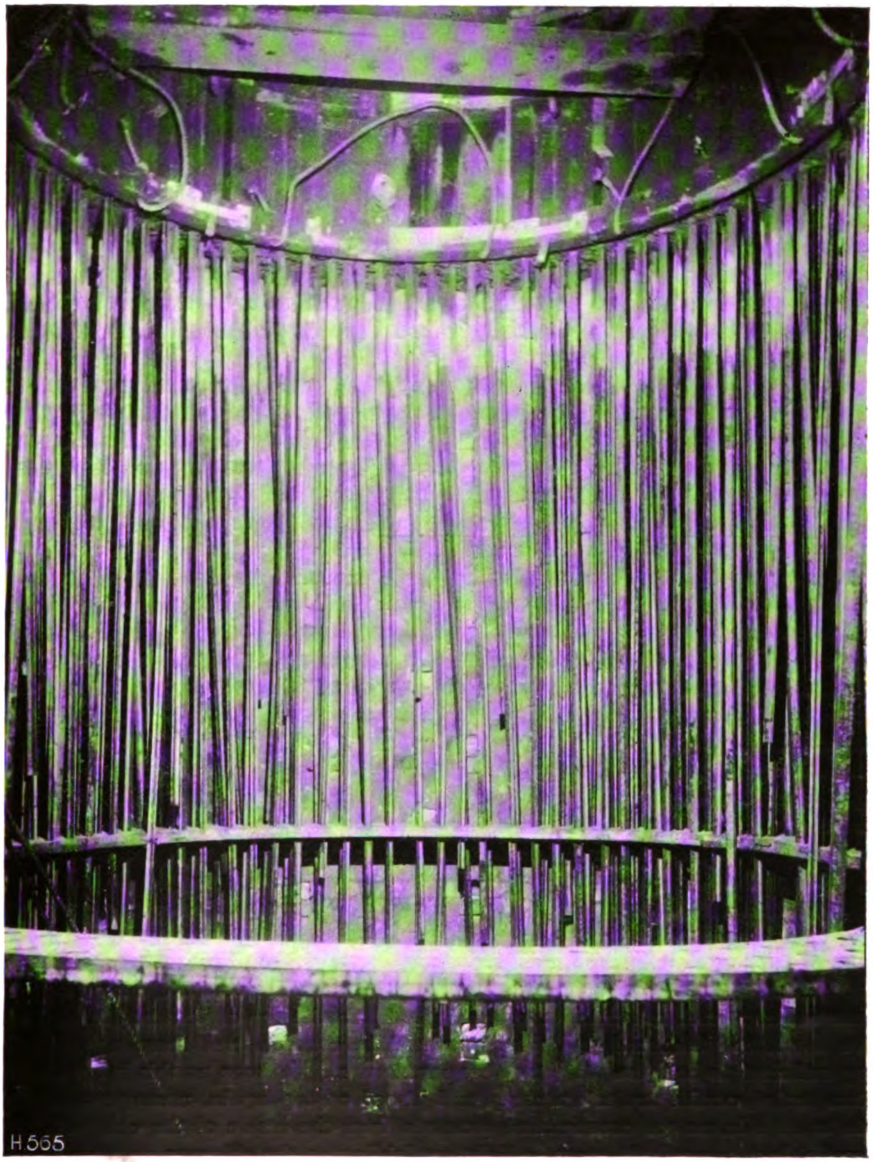
The west chimney has been at work since the beginning of March, and so far with satisfactory results, having been inspected twice since it was put to work. The writer is not aware, however, of any case similar to this where a reinforced concrete stack has been built inside an existing steel one.

The alternative that faced the company in this case was to completely remove the steel stacks, and build brick or entirely new reinforced concrete ones in their place, which would have cost two or three times what the reinforced concrete lining cost, without being any more durable or efficient.

Reinforced concrete has been largely used in America for chimney construction, and in the case of tall chimneys this form of construction comes out much cheaper than for brickwork. There have been some failures, but it appears that they were all due to the neglect of some of the now well-known conditions which are necessary to insure satisfactory results with all types of reinforced concrete construction.

The usual practice in chimney construction is to use a mixture of one part of high-class cement to three parts fine, clean, sharp sand. The sand should be free from any fine silt, and from the fact of it being fine sand requires more careful mixing than where a coarser mixture is used, and for the same reason the sand should preferably be fairly dry when first mixed with the cement, then turned over at least three times when it is being moistened.

In order to get a good bond between the concrete and the steel reinforcements, it is absolutely necessary that the concrete should be put in wet, as the failure of several chimneys has been due to the fact that the mixture was put in dry, the result being that the concrete did not adhere to the steel work, and also formed a weak, porous concrete.



View showing Reinforced Concrete Lining during Construction.

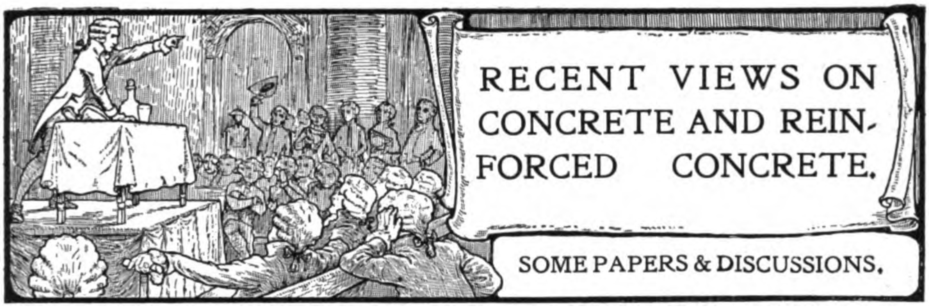
With regard to the design of concrete chimneys (independent of outside steel casing), this differs from the design of brick chimneys, due to the fact that the stresses are met in quite a different way. A brick chimney stands because of its weight, the outside diameter of the base being made so large that it cannot blow over, the stresses in the brickwork being entirely compressive. A reinforced concrete chimney is of much smaller size at the base, and would topple over if it could not sustain a tensile strain. A reinforced concrete chimney may, therefore, be treated as a beam fixed at one end and loaded on the side on which the wind is blowing, this side being in tension and the opposite side in compression; therefore, the steel reinforcement should be designed to withstand the maximum tensile stresses that are likely to occur. It is customary to assume a pressure of 50 lb. per sq. ft. of vertical surface, which corresponds to a wind pressure of 100 miles per hour. It is, therefore, necessary to have a proper number of vertical steel rods or bars all round the chimney to resist the pull caused by the wind pressure, and steel hoops must also be placed at intervals to stiffen the vertical steel, and prevent cracks due to difference in temperature between the interior and exterior, and especially to resist the vertical shear which corresponds to the horizontal shear in a beam.

With regard to the effect of exceedingly high temperatures on concrete, there seems to be hardly enough experimental data to decide what effect these will have on concrete after long periods of time, but temperatures up to 700 or 800 degrees F. do concrete no harm; in fact, concrete that has been subjected to such temperatures seem to set particularly hard, and as the boiler gases in most stations are usually nearer 500 degrees F., no trouble should be anticipated from this cause, provided the chimney is properly designed.

As concrete is a bad conductor of heat, the two or three inches next the surface exposed to the heat of the gases tend to expand to a greater extent than the outer surface, consequently it is not unusual to find small cracks on the outside of concrete chimneys due to this cause. This may be to a certain extent overcome by placing the horizontal reinforcements nearer to the outer surface, but these small cracks are not considered of any consequence, provided they do not run into one another for any great distance.

A large number of chimneys are built with a special lining for a third of the height from the bottom of the chimney, the object in view being to overcome this unequal expansion between the inner and outer surfaces, but care has to be taken to strengthen up the reinforcement at the point where the double wall becomes a single one, otherwise cracks are likely to occur.

The method of constructing a new reinforced concrete chimney is very simple. Two sets of inner and outer moulds are employed which are connected together by means of latches, enabling the moulds to be easily taken to pieces; after the first two sets of moulds, which correspond to the first two courses of concrete, have been filled in, the lower moulds are taken away and placed on the top of the moulds that were above them, the frictional resistance between the concrete and these upper moulds being sufficient to hold the weight of the next course. As soon as this is set the then bottom set of moulds are taken away and placed on top again, arrangements being made to do this, as the construction proceeds from the inside of the chimney, hence no scaffolding is required, except a light scaffolding as the chimney goes up to allow a rough ladder to be erected, and sufficient to support the gear for hoisting the material.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

Paper by Mr. A. ALBAN H. SCOTT, M.S.A.

THE BRITISH ALUMINIUM COMPANY'S WORKS.

A meeting of the Concrete Institute was held at the Royal United Service Institution, Whitehall, London, S.W., on June 30th, 1910, at 8 p.m., Mr. H. D. Searles-Wood, F.R.I.B.A., in the chair, on which occasion Mr. A. Alban H. Scott, M.S.A., read a Paper entitled "The British Aluminium Company's Works at Kinlochleven," which was profusely illustrated by lantern slides. The following is an abstract of the Paper.[*]

Generally.—Aluminium, the author stated, was now obtained electrolytically from bauxite, a clay containing a high percentage of aluminium oxide. The British Aluminium Company were now producing metal containing 97·3 per cent. pure aluminium. They had extensive bauxite mines in France and at Larne. The alumina was extracted from the bauxite at Larne, and from there sent to Foyers and Kinlochleven to be made into the commercial form of metal. The Company had also extensive works at Stangfjord in Norway, Orsieres in Switzerland, and at Greenock, and their rolling mills were situated at Milton in Staffordshire. The total water-power at the various works exceeded 60,000 h.p.

Kinlochleven is situated on the west coast of Argyllshire, and is separated from the county of Inverness by the Loch and river Leven, access being gained to the works by train so far as Ballachulish and Glencoe, thence by steamer up the Loch Leven, for a distance of about 9 miles, the new village and works being situated, as the name implies, at the top of Loch Leven. This district is one of the most rugged in the Highlands, and is noted for its magnificent scenery. The only road leading into Kinlochleven is from Fort William, a distance of 24 miles, and this road is not available for heavy traffic, nor was it available for use as access to the site during the course of construction of the works.

Kinlochleven works were started early in 1905, and the work was rapidly carried through, an average of about three thousand men being employed on the work continuously, and during the finer months of the year over five thousand were engaged upon the work.

Consultants and Contractors.—The consulting engineers for the dam, hydraulic works, and wharves were Messrs. P. W. and C. S. Meik, M.M.Inst.C.E.; for the electrical works, Sir Alexander Kennedy and J. W. Jenkins, M.M.Inst.E.E. The contractors of the dam and hydraulic work were Messrs. Sir John Jackson & Sons; for turbines, etc., Messrs. Jens Orten Boving & Co.; for the generators, Messrs. Dick Kerr & Co.; for the telephones and street lighting, Messrs. Johnson & Phillips; for the switchboard, control panels, and motors for No. 2 Factory, Messrs. Siemens

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[*] Various particulars and illustrations of these highly interesting works were published in this journal during 1908 and 1909 (*see* Vol. III., *p.* 486, and Vol. IV., *p.* 134).

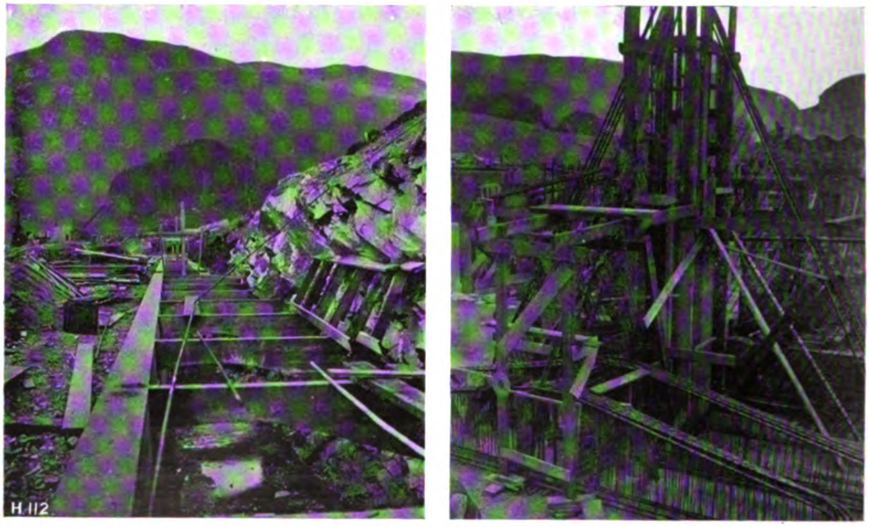
Brothers; for the village, power-house, No. 1 Factory, and staff houses, Messrs. McLaughlin and Harvey; and for No. 2 Factory, Messrs. McAlpine & Sons.

The author of the paper had the honour of being architect for the factory buildings and for the village, staff houses, etc. Mr. W. Murray Morrison, M.Inst.C.E., was the general manager of the Company, under whose direction the whole of the work was carried out.

The systems of reinforced concrete used were Coignet, Hennebique, and expanded metal. The cement used was supplied by the Associated Portland Cement Manufacturers (1900), Ltd.

The Dam. — The dam has been constructed at a distance of about 5½ miles from the head of the loch. By its means the water of three existing lochs was thrown into one.

The top of the dam is 1,068 ft. above the sea-level, the level of the three original lochs being 992 ft., 1,022 ft., and 1,028 ft. respectively. The catchment area formed by their unification is from 50 to 60 sq. miles, and as the rainfall is about 100 in. per annum in that part of Scotland, the possibility of a shortage of water and its harmful consequences is very remote. This gives the Kinlochleven works an advantage over a great many other hydro-electric stations, which are liable to run dry in summer.



Portion of Culvert—one side Reinforced Concrete, one side natural rock.

Reinforcement for a column, with spread foundations.

Reinforced Concrete Works at Kinlochleven.

The dam is about three-quarters of a mile long and 86 ft. high in the centre, the width at the bottom being 63 ft. and the width at the top 10 ft. The whole of the dam is constructed of concrete. The foundations are sunk 5 ft. 6 in. into the solid rock. The dam is surmounted by a tower, from which the valves at the outgoing conduit are controlled.

The water is conveyed from the dam along the mountain-side for a distance of about 3¾ miles in a reinforced concrete conduit, the inside section being 8 ft. by 8 ft., and the conduit has a steady fall of 1 ft. in 1,000 ft. Along the length of the conduit the various side streams from the mountains are picked up so as to take advantage of all the water available; the main penstock chamber is at the junction of the concrete conduit, and the six 39-in. diameter iron pipes form the main pipe line. Here the main control of the water supply is operated.

The pipe line, which is about 1¼ miles in length, conveys the water down to the main distributing valves, which are placed immediately above the entrance of the water to the power-house, the water passing through these valves to the bus-pipes and thence to the distribution pipes (which are below the general level of the floor of the power-house) direct to the nine high-pressure turbines (Pelton wheel type) of over 3,200 h.p.

each, and two 930-h.p. turbines. An output of 20,000 k.w. at 250 to 275 v. is secured by means of 18 generators, each capable of running at full load day and night continuously for months at a time, at a normal speed of 300 r.p.m.

Site, Power House, and No. 1 Factory. — The site, before any works were commenced, was simply in the usual condition of the uninhabited Highlands.

The ground was very varied and treacherous, large tracts of peat overlying portions of the site. The levels also were extremely awkward for arranging the railway, village, and factories on convenient sites, and a very large amount of excavating, not only in soft material, but also in some of the very hardest stone, had to be carried out.

The foundations of the power-house are constructed of ordinary plain concrete, and in these foundations is provided the bus-bar chase, tail-race, and subways for the pipe connections. The floor of the power-house is tiled with red Cheshire tiles and Hawkesley's treads. A powerful electric crane is installed here, so that any part of the machinery can be moved by the crane. The roof is formed of steel trusses, steel and wood purlins, roof-boarding, felted and slated with Ballachulish slates. The main outside walls are constructed of local stone, the dressings being of Kintallen granite and artificial stone made with the local rock.

No. 1 Factory, which contains all the electrical furnaces, is built of similar materials, and covers a very extensive floor area. The workshops are arranged along one side of No. 1 Factory, and abut on to and have access from the power-house and furnace-room. The main stores will be built on the south side of the general factory buildings.

The Carbon Factory. — The process for manufacturing aluminium requires a great amount of carbon, and in order that a plentiful supply of electrodes may be always to hand the British Aluminium Company have erected a carbon factory for its manufacture at Kinlochleven. In constructing this building a very treacherous subsoil was come upon, which resulted in part of the foundations having to go about 55 ft. below the general floor level. The whole of the foundations are formed of reinforced concrete on the principle of spread foundation slabs, stiffened by cross and longitudinal beams. The columns are carried from the foundation slabs up to the underside of the top beams, these beams carrying the very heavy stone walling; the columns carry the walling and roof, and also in some cases the bunkers and contents. Some of the columns take over 250 tons. The upper reinforced concrete floors are constructed to carry from 8 to 20 cwt. per ft. super and concentrated heavy machinery, such as motors, etc.

The walls, with the exception of those which are made temporary for the purpose of future extensions, are constructed of coursed random rubble built in cement, the stone being local rock, and the walls vary in thickness from 15 in. to 36 in., many of them going to a considerable height. The roofs generally have steel trusses of various spans with steel and wood purlins; in some cases the roofs are boarded to receive the Ballachulish slates, and in some of the rooms the slating has been fixed direct on small steel purlins without any woodwork at all. Two large flats are constructed of reinforced concrete, and it is interesting to note that these flats are quite watertight, although no roof covering has been put on.

In this factory overhead reinforced concrete bunkers are constructed to carry 4 tons, 10 tons, 60 tons, 140 tons, 350 tons, and 2,000 tons, the latter being carried on 16 in. reinforced concrete columns each 2 ft. 3 in. square. The design and work of these are of a very complicated nature, and the author believes the 2,000-ton bin is the largest bunker constructed entirely of reinforced concrete without the aid of R.S.J.'s

Roads, Lighting, Sewage and Water Supply.—Very extensive roads have been laid out and constructed.

The whole of the factories, streets, houses, cottages, and other buildings are lit by electric light.

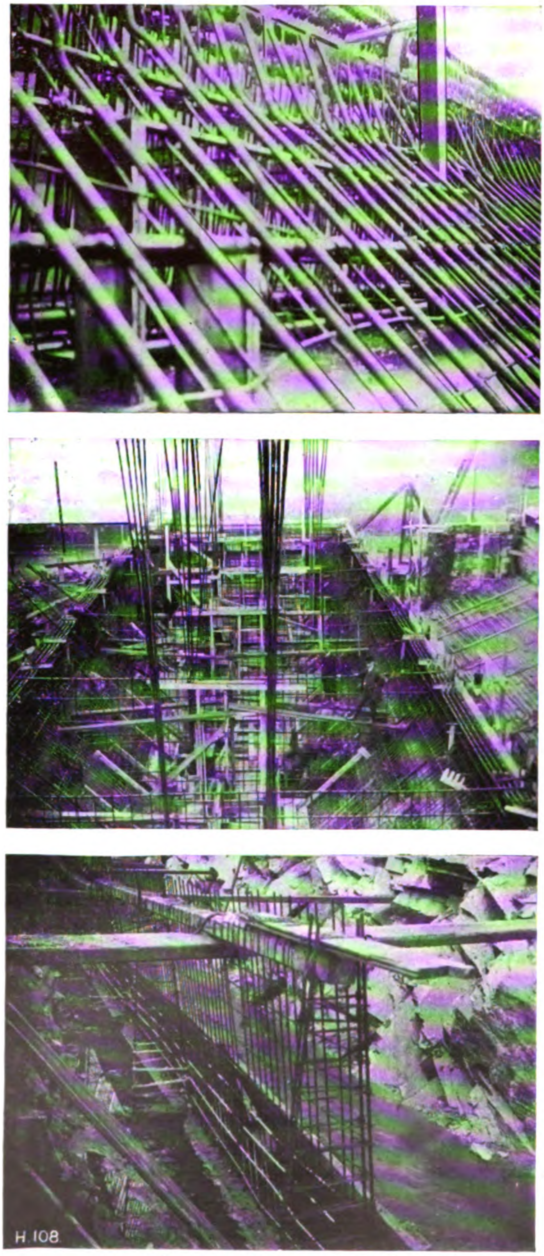
The general drainage of the village is carried on with 3 in. to 18 in. diameter stoneware and iron pipes. The surface water has a separate system of large culverts. Septic tanks will deal with the sewage at the outfall, the surface-water outfalls discharging direct into the river. The surface-water culverts are constructed in various ways, some being open with the sides formed of rubble masonry, others being open reinforced concrete culverts, whilst there are also circular and square forms in reinforced concrete.

The water supply for the village is obtained from the catchment area of Corriemora. A comparatively small dam has been constructed, so that the reservoir will contain when completed sufficient water for a population of over 6,000. Iron pipes have been used throughout the whole of the domestic supplies.

Staff Houses, Offices, Laboratory, etc.—The staff houses naturally vary in size and accommodation, but they have generally been constructed with ordinary concrete foundations and 6-in. concrete over the area of the site, the walls being of rough rubble of varying thickness, from 15 in. to 22 in. The walls are in some cases coated with cement rough-cast, and the inside of all external walls battened and lathed and plastered. The interior walls are formed of brickwork in cement, the floors being as usually constructed in the South. The roofs, however, are considerably stronger than usual, and have boarding and felt, and are slated with Ballachulish slates, which are very thick and heavy. These slates give an excellent appearance to the roofs. The slates are fixed in diminishing courses, which again helps the appearance, and this district having such a little sun, the thick and rugged slates give a greater relief than the thin and even slates. The Ballachulish slates seem to be particularly adaptable and serviceable for that part of the country, as they withstand the very severe weather.

The offices and laboratory are constructed of similar material as the staff houses. In all these buildings the lintels are of reinforced concrete, and the upper floor of the offices is also of this material.

Cottages, Cottage Flats, Single Men's Quarters, Shops, Administration Block. — The housing accommodation for the general employees consists of various classes of buildings, which can be generally divided as follows:—*a*, Self-contained cottages; *b*, Cottage flats; and *c*, Single men's quarters.



1 and 2. Reinforcement for Bunkers.
3. Reinforcement for one side of Culvert.

REINFORCED CONCRETE WORKS AT KINLOCHLEVEN.

Permanent shops have been erected, including the necessary bakehouses, stores, etc.

The earliest forms of houses were constructed of two half-brick walls from the ground line right up to the eaves with 2¼ in. cavity between, and were rough cast on the outside and plastered direct on to the brick walls inside.

The lower cottage flats and single men's quarters and administration block are built on quite a new method, the whole of the main constructional work being of reinforced concrete, the walls being formed of reinforced concrete posts and beams, and the panels thus formed by the posts and beams being filled in with two 1½-in. slabs, with 2-in. cavity between, and the whole face cement rough-casted.

This form of construction had, the author thought, to a very great extent solved the difficulty of obtaining well-built, solid and efficient houses, at such a low cost that it was possible for the lowest-paid class of labourer to be housed in a more decent manner, with a lower rent than had hitherto been the case.

Railways, Wharf and Jetty.—An electric railway has been constructed from the factory to the wharves at the head of Loch Leven; the total length is about three-quarters of a mile (double track).

The wharf and jetty are constructed of wood and have electrical cranes, both stationary and movable, for quick loading and discharge of steamers.

The largest boat that has used the loch was 1,500 tons displacement, carrying a cargo of nearly 1,000 tons. Until these works were constructed, steamers of only a very small tonnage could use the loch, as at one part, called "The Narrows," it was very shallow even at high water. This, however, has been dredged, thus allowing comparatively large vessels free course.

A discussion followed, in which Mr. W. G. Kirkaldy, A.M.Inst.C.E., Mr. T Malcolm McAlpine, A.Inst.C.E., Mr. H. K. G. Bamber, F.I.C., A.M.Inst.C.E., Mr. G. C. Workman, Mr. Lucien Serraillier, Mr. Percival M. Fraser, A.R.I.B.A., Mr. J. Ernest Franck, A.R.I.B.A., and Mr. H. D. Searles-Wood, F.R.I.B.A., took part.

The meeting then terminated.

INSTITUTION OF MUNICIPAL ENGINEERS.

NOTES ON THE USE OF PORTLAND CEMENT CONCRETE.

By SPENCER SILLS, M.Soc.Eng.

The following is an abstract of the Paper read by Mr. Spencer Sills, M.Soc.Eng., on "Notes on the Use of Portland Cement Concrete," before a Southern District Meeting of the Institution of Municipal Engineers held at Brighton, on June 18th.

Generally.—The use of Portland cement concrete has had such a rapid growth during the last few years, and its adaptability to the most unusual purposes is every month more widely demonstrated, that it behoves the municipal engineer above all others to become as familiar as possible with its characteristics and uses. There is little probability of getting to the depths of the subject in a paper of this length, nor has the writer a hope of presenting any fresh features or data for the general enlightenment, but it is well to occasionally turn over old items of information in order to brighten up half-forgotten knowledge and to keep our minds fresh to well-known facts.

The first and most important point with regard to concrete is the selection of a sound cement; the second, the choosing of a suitable and properly constituted aggregate, and the third, but by no means the least consideration, is the mixing and manipulation. Let the engineer's calculations and design be never so perfect, let the material be never so good, the apathy of the man with the shovel is sufficient to ruin the most completely arranged scheme, unless he is efficiently supervised.

Tests.—It is a very general complaint that the ordinary tests for soundness as applied to cement require too much time to be of real service upon the works, as the particular consignment under notice is beyond recall before the tests are completed.

It is true, a known brand of cement may be specified and tests may be made of that brand extending over months prior to the commencement of the works, but a fluctuation in quality is possible with the best, and substitution and adulteration is not unknown. Again, the tests are often delegated to some inexpert individual on the works whose results are not at all convincing.

Generally, one relies upon a seven days' tensile test or some more rapid and inaccurate trial, and is often satisfied with a high tensile strength which may be entirely misleading, as the cement may show a tardy increase in strength for longer periods, while on the other hand a cement yielding a moderate result of 350 lb. to 400 lb. per sq. in. at seven days may show a steady and substantial increase at fourteen, twenty-one, twenty-eight days and onwards. Probably the best way out of the difficulty as the matter stands at present is to entrust the testing to an expert of repute, to whom the origin of the cement is unknown.

The cement should of course be stored in a dry, cool place, and although growing opinion appears to be that a good cement should need no aeration, the experience of the writer does not support this view. Batches differ greatly, and during a boom in the trade one is likely to be surprised if he pins his faith too firmly to this view.

Aggregates.—Choice of an aggregate is often limited to local material which may be altogether unsuited to the purpose, and herein lies a cause for failure which would undoubtedly be attributed to the cement. Dr. Owen says, "It is quality in aggregate which I am convinced is responsible for the production of bad concrete."

When strength is required, hardness and toughness in the aggregate are indispensable, but for fireproof construction other qualities have to be considered, and where lightness of construction is a matter of moment and strength is not so important a still different class of material may be used. In no circumstances should such considerations be sacrificed to the fetish of cheapness in preferring an aggregate easily procured locally to a more suitable material which has to be imported at an increased cost.

The aggregate must be clean and free from loam, clay, mould, vegetable growth, animal refuse, dust, or any matter foreign to the nature of the material, and, if necessary, it should be repeatedly screened and washed to render it suitable for its purpose. Pit gravels are often mixed with fine loamy clay, which it is safest to eliminate from the aggregate if a strong concrete is desired, and such material moreover frequently contains a quantity of softened and partially decayed stones and spongy mineral concretions which it is wise to reject for important work.

Broken brick must be freed from dust and mortar rubbish; burnt ballast must be hard burned, free from lime and sulphur and from unburnt particles; coke breeze should be from gas retorts or coke ovens, free from coal, clinker, cinder, ash, or substances which will not float on water; furnace clinker should be hard, well burned, free from dust, shale, lime, ash, and metal scrap or scale; blast furnace slag should be from pig iron furnaces, free from basic slag and well washed to remove dust and sulphur. Broken pottery or tile is unsuitable for mixing with an aggregate, as the pieces bridge over voids and prevent perfect consolidation.

An imperfectly apportioned or graded aggregate requires more cement to make a strong, dense concrete than a more exact mixture, and the usual specification, which simply provides a gauging of 1 to 3 or 1 to 6, does not ensure the provision of the due amount of fine material required to fill the voids.

The increasing popularity of reinforced work is thrusting home the fact that concrete mixing must needs be an exact operation which allows of nothing which savours of the old rule-of-thumb methods. All voids must be filled as completely as possible with the mortar of cement and sand, and to ensure this the aggregate must be carefully tested and the proportion of fine material adjusted to the needs of the case.

An aggregate composed of grains of a uniform size contains the highest percentage of voids, which may amount to 60 per cent. or more of the mass—grains of varying sizes are therefore needed to effectually consolidate the concrete. The maximum size for particles of the aggregate depends of course upon the nature of the work, smaller gauge being demanded for reinforced work in order to ensure the uniformity in the mass, and close intimacy with the reinforcement. The usual practice is to screen through sieves of the sizes as under:

Artificial paving	¼ in. to ⅜ in.
Floors	½ in. to ¾ in.
Walls	1 in. to 2 in.
Foundations	2½ in.

"Plums" in ordinary foundation work should be carefully deposited well away from one another and from the sides and angles of the mass, but never allowed in reinforced work.

Proportioning the Materials.—To estimate the quantity of sand and cement required to make a sufficient mortar to form a dense concrete with the coarse aggregate, a vessel of known capacity is filled to the top with the coarse particles, and water is poured in from a graduated measure until the vessel is filled to the brim. The quantity of water required to fill up the voids in the coarse aggregate represents the proper proportion of sand. A like proportion of coarse aggregate and sand is now put into another vessel, shaken down and levelled to the top, and water is added to this from a graduated measure, as before, to ascertain the amount of cement required. Absorbent aggregates must of course be well soaked before the experiment is carried out.

Consistency of the Concrete.—The water for mixing concrete must be clean and entirely free from matters in suspension. Stagnant pond water is most unsuitable, as it is frequently swarming with animal and vegetable life and chemical impurities. Concrete requires about 25 per cent. to 30 per cent. water to form a homogeneous mixture, and the mass should be well turned dry until the whole is thoroughly mixed, and turned again quickly, when wetted, several times, until of a uniform colour. When deposited the concrete should show just wet upon the surface. More water than this floods the cement and washes it away from the aggregate, and less water does not allow of the full reaction of setting. If the aggregate is of a porous or absorbent nature, such as broken brick or stone, it should be well soaked before mixing, otherwise the aggregate will absorb water when deposited and impair the setting operation, and in these circumstances it is quite possible to get a weak concrete although using the full quantity of cement.

Accurately-measured gauges for apportioning quantities upon the works is of the greatest importance, and their intelligent use a matter for close supervision. The sometime method of filling the aggregate gauge, levelling up and placing a bottomless cement gauge on the aggregate for filling, leaves too much to chance in the variation of the quantity of cement. A more accurate gauge for cement is a metal vessel, but undoubtedly the correct way is to apportion the cement by weight, taking 100 lbs. weight as representing one cube foot of sand voids.

What to Avoid.—The secret of success in concrete work lies in the knowledge of what to avoid, and may be briefly summarised as follows:—

Avoid an unknown cement, cement delivered in unbranded sacks or casks, or one of foreign manufacture. British-made is good enough, and is branded. Avoid lumpy or caked cement. Avoid a quick-setting cement. Avoid accepting the first aggregate to hand; choose the best obtainable for the purpose. Avoid the acceptance of an aggregate on sample; see it in bulk. Avoid the use of a natural aggregate without knowing its history, and insist upon screening and apportioning sand. Avoid muddy water or water of a decided colouring. Avoid slovenly methods of gauging and mixing. Avoid sloppy concrete or semi-dry mixtures. Avoid mixing quantities of concrete which cannot be immediately disposed of. Avoid the use of dead concrete. Avoid frost, and carefully protect finished work. Avoid laying concrete in water. Avoid heavy or long-continued ramming. Avoid earth and rubbish falling upon and mixing with concrete. Avoid weak shuttering or sparse timbering. Avoid the removal of centering, shuttering, or timber until the work is hard. Avoid the temptation to generalise in specifying.

DISCUSSION.

Mr. B. W. Veale: They were told by the author to avoid laying concrete in water. He wrote and asked Mr. Sills what he meant, because concrete was rather a good thing to be used in water.

In his reply that gentleman said: "This requires some further explanation, as all such attempts at brevity do. It would have been better perhaps to have said 'Do not deposit wet concrete in water.' What I wish to convey is this: that throwing concrete in water washes out the concrete from the aggregate, and it is either flooded or deposited unevenly. I have seen instances of very poor results from this practice when really good concrete was used. With a little scheme water can generally be dammed back, drawn off, or diverted until the concrete has attained at last its initial set."

The paper was of special interest to him (Mr. Veale) because he had had a great deal to do with concrete. In a drainage scheme the specification (of a Westminster engineer) provided that no concrete was to be placed through water. He asked what this referred to, and received the answer: "What it says." The specification also provided that the new method of mixing sand with the cement before it was mixed with the aggregate was to be insisted upon. There was a difficulty in getting the contractor to adopt this method, as it was new to him. He (Mr. Veale) had seen many thousands of tons of concrete mixed, and it struck him as a novelty, but he had been thoroughly converted to it, and now never dreamt of adopting any other system, for by such a method they had a guarantee that no portion of the cement would be lost. The other difficulty he had had was to ensure a proper proportion of sand and cement. The method adopted was to ascertain the exact proportion of sand to fill up the interstices, and the amount of cement to fill up in the sand, both being arrived at by the volume of water. The aggregate of the beach was a continually varying proportion, and the aggregate must be filled before. It was difficult to get the exact proportion, but the exact proportion was the only way.

Mr. A. E. Fuller (Hove) remarked that they made foundations for the groynes on Brighton front some years ago by putting concrete into bags. It was put in dry, so that the actual mixing with water occurred under the sea. The work had lasted for fourteen or fifteen years, and there was no sign of ill-effects whatever.

Mr. A. E. Prescott (Eastbourne) said he had had a similar experience to the last speaker as regarded sea defence works, and carrying out sewers to sea. He had deposited hundreds of tons of concrete in the sea with success. He placed it in bags in a dry state, and dropped it down. He believed in the old-fashioned system. He had read a good deal on the subject, but he believed with the author of the paper that to a great extent they were dependent upon the ganger, or the man who was charged with the mixing of the concrete.

Mr. B. A. Miller (Seaford) observed that in his case the whole of the foundations of the breakwater were entirely built of hundreds of tons of concrete in bags mixed dry and dropped down. The material was dropped from a hopper barge, and sometimes the sea was not smooth. He had been down in a diving dress and examined the foundations, and found naturally that many of the bags lay a little out of place. The consequence was that within the last few years considerable expense had had to be incurred in repairs.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course or construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

GRAFTON BRIDGE, AUCKLAND.

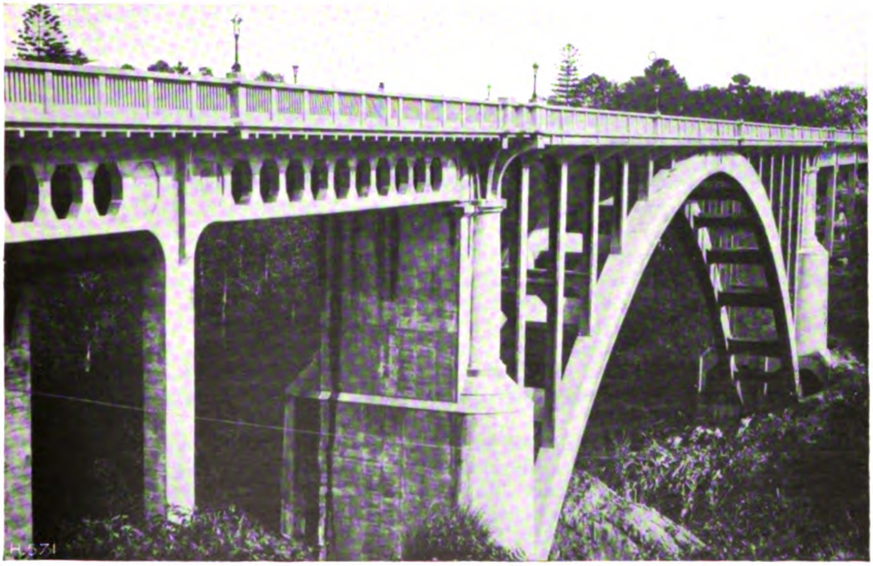
THE construction of the Grafton Bridge was first mooted by the City Council of Auckland in 1905, in consequence of the fact that the foot bridge which spanned the Cemetery Gully, dividing Symonds Street and Grafton Road, had been condemned as unsafe. In consequence of the discussion that then ensued designs were furnished by the Ferro-Concrete Co. of Australasia, Ltd., and by the American Bridge Building Co. for a reinforced concrete bridge and steel bridge respectively. Nothing definite was done until 1906, when it was decided by the Council to ask the authority of the ratepayers for a loan of £30,000 for the construction of a traffic bridge. A poll of the ratepayers favoured the construction of the road traffic bridge, and the necessary authority for the borrowing of £30,000 was given.

In March of 1906 Mr. Walter E. Bush, A.M.Inst.C.E., was appointed as City Engineer to Auckland, when he was asked to report on the provision of a new bridge across the gully.

He advised that a road traffic bridge should be provided, and that it should be constructed in a straight line from Symonds Street to Grafton Road, and at one grade of approximately 1 in 70; that alternative designs and tenders should be obtained for a bridge in reinforced concrete and steel.

Two tenders only were received, viz., from the Ferro-Concrete Company of Australasia for a bridge in reinforced concrete at a cost of £31,918, exclusive of kerbing and paving, and from Messrs. J. McLean & Sons for a steel bridge to be manufactured by the American Bridge Building Company at a total cost of £28,739 12s. 6d.

The tenders were referred to Mr. Bush to be reported on, and after giving them careful consideration, he recommended the acceptance of the first-named tender on the ground that the maintenance of a reinforced concrete bridge would not be so much as



GRAFTON BRIDGE, AUCKLAND.

that of a steel one, and that from an æsthetic standpoint the design in reinforced concrete was far preferable to that in steel.

The bridge is now virtually completed. Its total length is 960 ft., a short span having been added at the Grafton Road end, in consequence of the failure to obtain permission to close a blind road. The length is divided as follows:

1 span 35 ft.
1 span 37·5 ft.
4 spans 75·5 ft. each.
1 main arch span of 320 ft., flanked on each side by 2 main piers occupying at top 18 ft. each.
2 spans 78·5 ft. and 80·5 ft. respectively.
1 span 42 ft.

All approach spans consist of straight girders, the three shorter ones being of solid design and the others of open panel. There are three girders to each span.

The main feature of the bridge is, of course, the 320-ft. 3-hinge arch (with a rise of 84 ft. from centre of abutment hinges to centre of middle hinge), which is shown in our frontispiece and which consists of two parallel ribs ranging in size from 6 ft. × 4 ft. 2 in. at the abutments to 9 ft. 9 in. × 4 ft. 1 in. (in the girder) to 5 ft. × 4 ft. at the centre hinge, connected by wide ties of reinforced concrete 8 ft. 4 in. × 20 in. haunched 18 in. each way into the rib and spaced at 21 ft. horizontal centres. The end hinges rest on solid abutments or skewbacks of concrete with a small amount of reinforcement, there being 720 cu. yd. of concrete in main abutments. These abutments rest upon a foundation consisting of a sort of sandstone, known locally as "papa" rock, and are quite independent of the large piers previously referred to, so that the movement in one would not necessarily affect the other. The hinges themselves, which consist of cast steel, rest on grills made up of steel H girders and plates, the centre hinge being treated in like manner, the grills being built into, and surrounded by, concrete.

The superstructure consists of seven piers of T section, the T being 3 ft. × 6 in., and the remainder 2 ft. 6 in. × 10 in. spaced 18 ft. apart in the clear. At the abutment the decking is carried by the cantilever, which projects 7 ft. from the end pier, a similar cantilever being constructed from the main pier over the abutment to meet the one referred to. The three highest piers on each half are braced by horizontal transverse beams of T section, spaced at intervals of approximately 30 ft. On each pier rest transverse girders 3 ft. 7 in. × 10 in., with haunches at each bearing; the actual deck system on the main span consists of five secondary beams, each 1 ft. 8 in. × by 10 in., running parallel with the direction of the bridge, the deck itself being of reinforced concrete a full 6 in. thick. The kerbing is situated over the outer beam in each case, the footpath being carried by a cantilever consisting of a deep haunch occurring at each transverse girder and by a decking 5½ in. thick in between. A further secondary beam 12 in. deep and 6 in. wide connects the haunch beams under the parapet.

The open panel girders are 9 ft. deep × 15 in. wide, there being, as previously stated, three girders in the width of the bridge. These girders are supported by piers.

The piers are formed by two solid piers 5 ft. × 4 ft., slightly reinforced with steel and connected at top by a deep girder or curved beam to carry the middle girder. The short spans, as before described, are ordinary solid girders, the two at the Symonds Street end being 3 ft. 9 in. × 15 in., and that at the Grafton Road end being 3 ft. 9 in. × 15 in.

The deck system in the case of the straight girder spans is the same in all instances, and consists of transverse secondary beams 2 ft. 6 in. deep at the middle girder, diminishing to 1 ft. 6 in. depth at the outer girder, and of a uniform width of 6 in., and continued beyond the outer girder in the form of a cantilever to support the footpath and parapet.

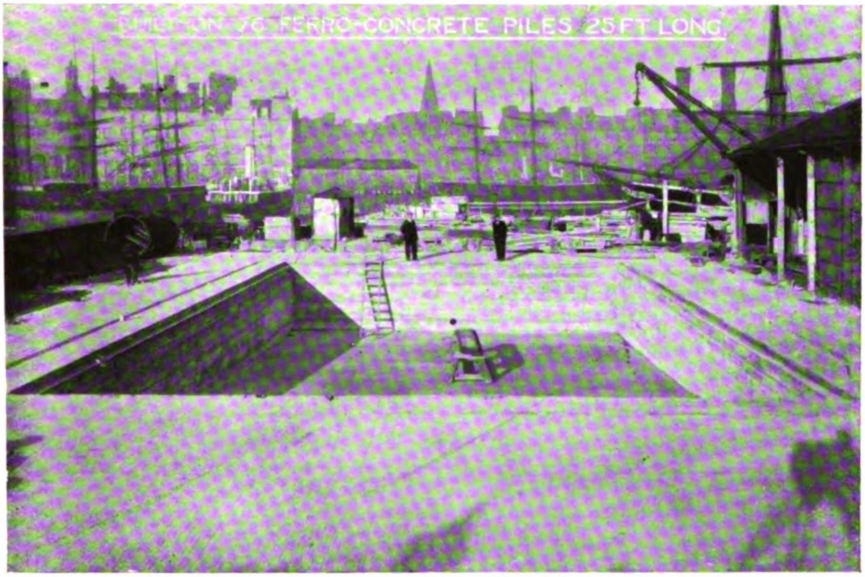
The decking on carriageway is 6 in. thick, that of footpaths being 5½ in., including layer of 1½ in. of fine concrete. The parapets are 4 ft. 9 in. in height, and constructed throughout of reinforced concrete. In the top member of the parapet is fixed black iron tubing to receive the cables for the electric lighting of the bridge.

The construction of the bridge has occupied two and a half years, and has been carried out by the Ferro-Concrete Company under the supervision of their Chief Engineer, Mr. R. F. Moore, who is responsible for the design of the bridge. In this latter work he was assisted by Mr. C. Rosegger, who made most of the calculations in connection with the bridge.

Satisfactory tests of the bridge have been carried out; the first consisted of a test of the main span, and was accomplished by loading the Symonds Street half with 292 tons of road metal, equal to a load of 113½ lb. per sq. ft. The placing of this metal was commenced on Saturday and completed on Tuesday morning, the total amount of deflection registered being ⅛ in., but owing to the length of time which elapsed in the placing of the load and the many changes of temperature which were experienced during such placing, too much notice must not be taken of this figure.

On the Thursday following the Tuesday, the road metal having been all removed, the deck work was tested by the passage of two steam rollers weighing together 32 tons, which were simultaneously run over from Symonds Street to Grafton Road. Careful readings of the deflectometers were taken during the return journey from Grafton Road to Symonds Street. In all cases the results were extremely satisfactory, the movements of the deflectometers being quite normal. The maximum deflection registered on the main span was $\frac{1}{12}$ in. and on the girder span $\frac{1}{15}$ in.

We are indebted to Mr. Walter E. Bush, A.M.Inst.C.E., City Engineer, Auckland, for the above particulars and photographs.



REINFORCED CONCRETE SWIMMING BATH, DUNDEE.

SWIMMING BATH, DUNDEE.

THIS work, constructed at Earl Grey Dock in the River Tay, Dundee, furnishes another example of the application of reinforced concrete to the construction of swimming baths.

The internal dimensions of the bath are 75 ft. 6 in. long by 35 ft. 6 in. wide, the depth varying from 4 ft. 9 in. to 8 ft.

There is a raft surrounding the bath which brings the overall dimensions of the structure to about 143 ft. by 62 ft.

There are 75 reinforced concrete piles of lengths varying from 18 ft. to 25 ft. driven singly and in pairs. These piles serve to support the bath and raft and prevent any upward movement of the bath due to the exterior pressure of the surrounding water when the bath is empty and the tide high.

The floor of the bath proper is comprised of transverse beams 8 in. × 14 in. and longitudinal beams 6 in. × 12 in. resting on slabs on the heads of the piles and is entirely supported by these piles, the whole connected with a floor slab 5 in. thick.

The walls of the bath are 5 in. thick at the bottom tapering to 4 in. at the top and reinforced about every 12 ft. 6 in. by columns 6 ft. × 5 in. or 6 ft. × 7 in. as necessary according to their position.

The raft is designed for the uniformly distributed load of 1½ cwt. per super. ft. as well as the loads to be brought by the steel stanchions and brick walls of the proposed superstructure.

On three sides of the bath there is a pipe alley in reinforced concrete 3 ft. 3 in. wide, having a slope of 1 in 150 down to the sump, into which nine outlet channels from the bath discharge.

The work was executed on the Hennebique system for the Dundee Town Council, to the designs of Mr. J. Thomson, M.Inst.C.E., burgh engineer, by the Yorkshire Hennebique Contracting Co., Ltd., of Leeds, the details of the reinforced concrete work being prepared by L. G. Mouchel & Partners, Ltd., of 38 Victoria Street, S.W.

HARTLAKE BRIDGE, NEARING COMPLETION.

HARTLAKE BRIDGE.

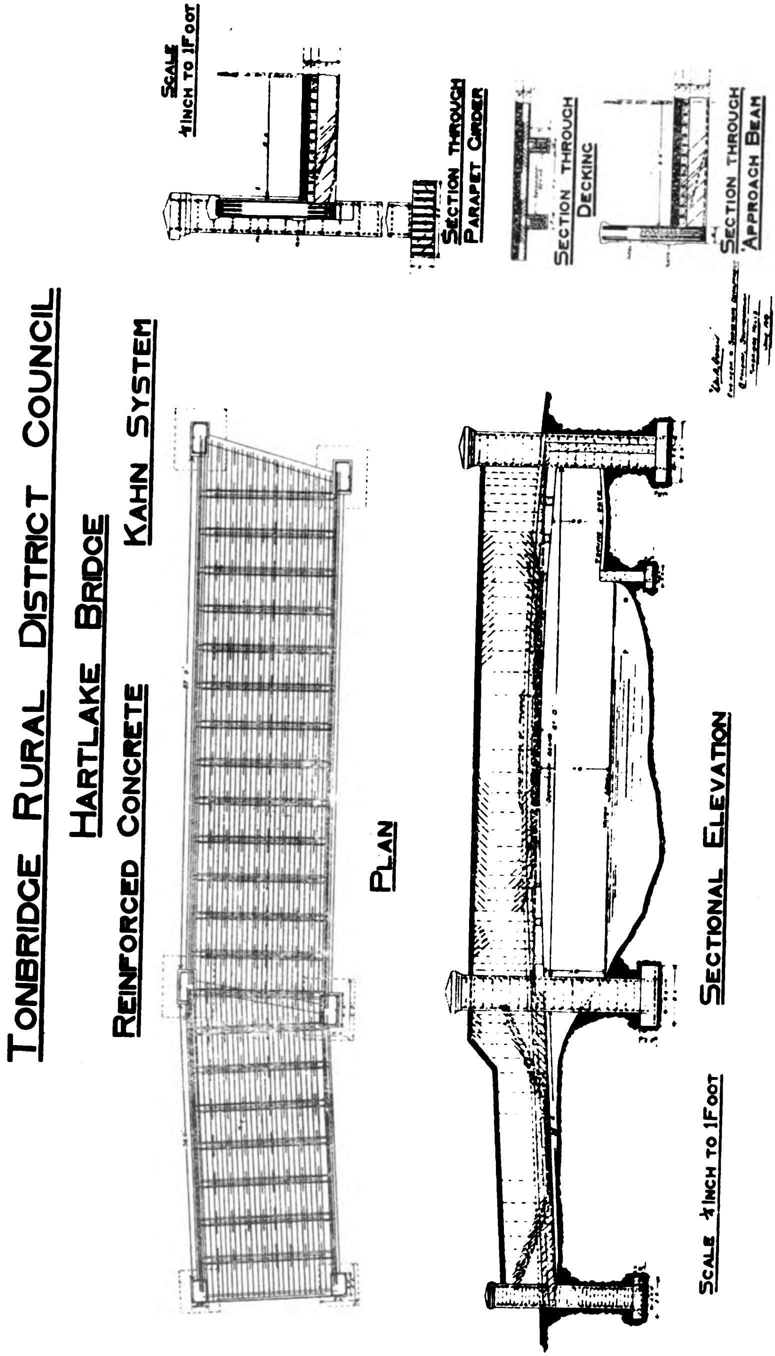
IN 1853 a wagon containing some fifty hop-pickers was being driven across the Hartlake Bridge, and, as would appear from the report which was presented to the Medway Co., the wagon was driven against the rails forming the approach to the bridge on the Tudeley side, which had given way, with the result that some thirty persons were precipitated into the river and drowned.

The old structure has been demolished, and in place thereof a new bridge of reinforced concrete on the Kahn system has been constructed.

The design of the bridge shows a span of 67 ft., and is 16 ft. in width. It is carried on two parallel girders, and the decking is 7 in. thick; the reinforcement of the girders and slab was of Kahn Trussed Bars, and the designs were prepared by the Trussed Concrete Steel Co., Ltd., Caxton House, Westminster.

The contractors experienced considerable difficulty with the foundations and with the construction generally, by reason of the heavy floods while the work was in progress.

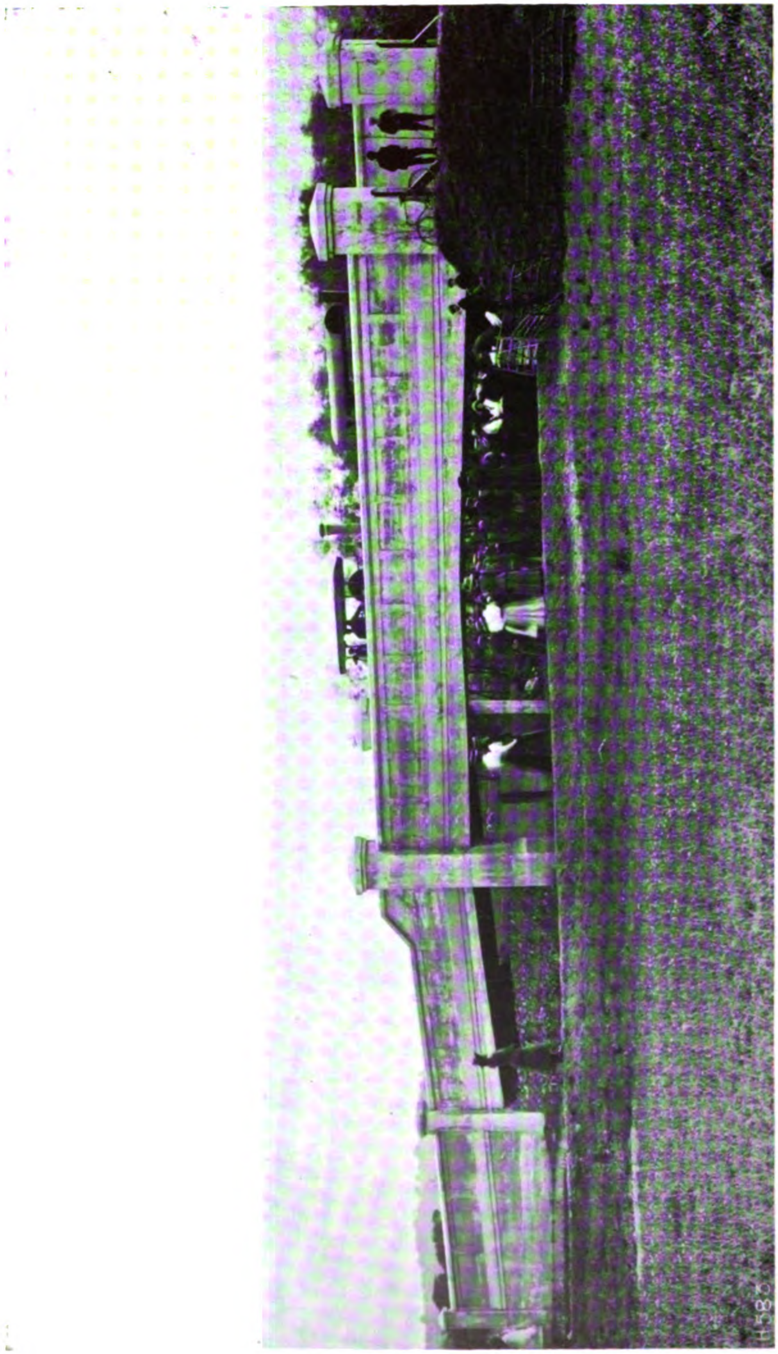
The bridge was formally tested on June 10th, the specified test being two steam rollers with 25 tons total weight running in any direction. A further test was made by



Plan, Elevation and Sections.
HARTLAKE BRIDGE.

running a steam roller coupled to a traction-engine drawing three trucks of granite kerb, and with a total weight of 55 tons, the deflection was only 1-64th in. in the centre.

After the load was removed no permanent set was observed. The concrete was composed of ¾ in. crushed Thames ballast and fine Thames sand in the proportion of 2⅓ of ¾ in., 1⅔ of sand, and 1 of cement, the amount of the sand being sufficient to fill the voids in the ballast as ascertained by water. The bridge was tested in the presence

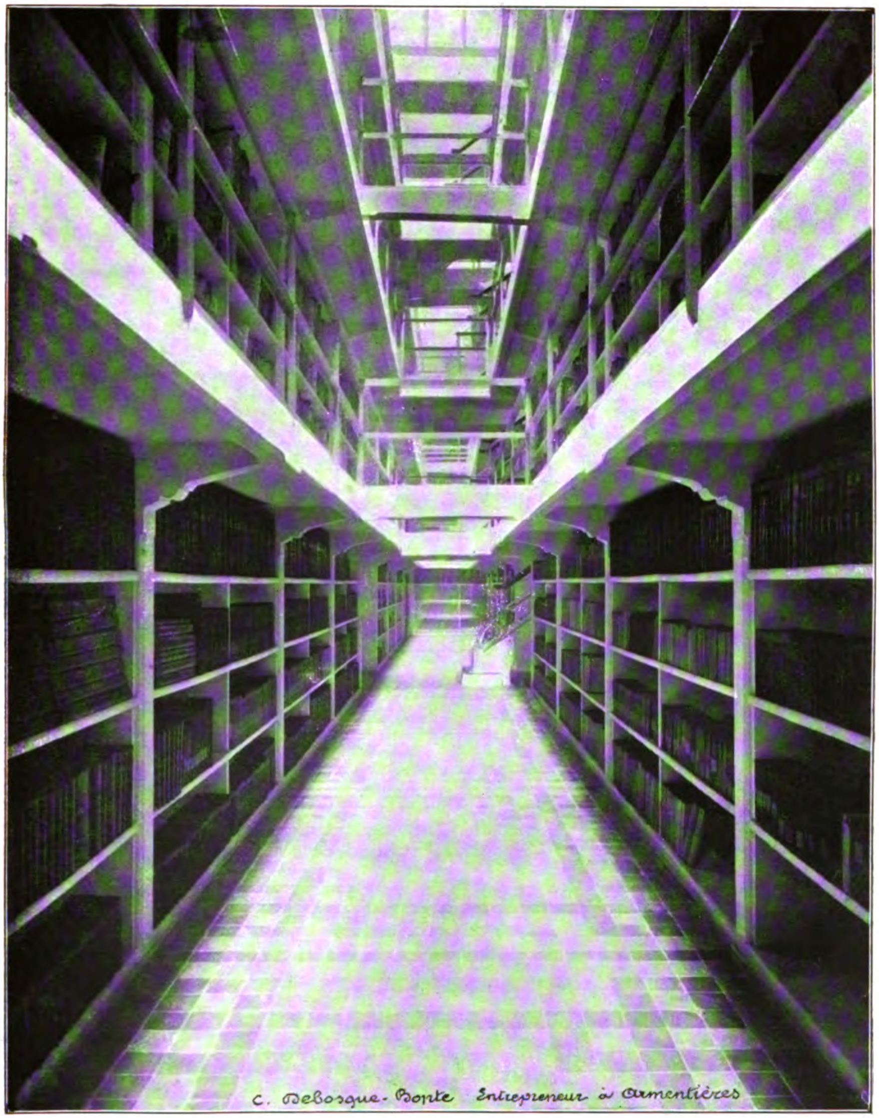


View showing Test Load of 55 tons on bridge.
HARTLAKE BRIDGE.

of the Engineer of the Tonbridge Rural District Council and a large number of interested spectators.

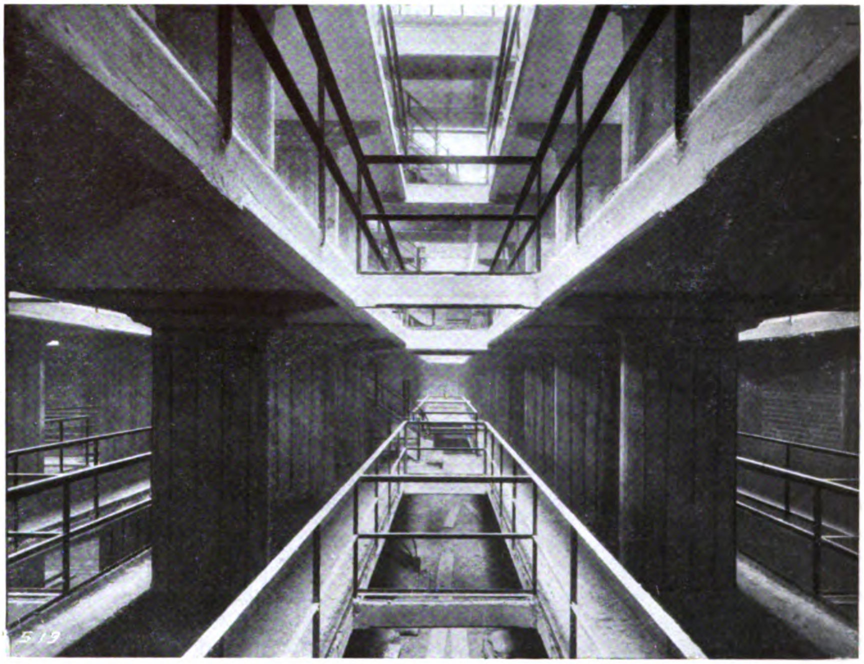
DEPOT FOR GOVERNMENT ARCHIVES AT LILLE.

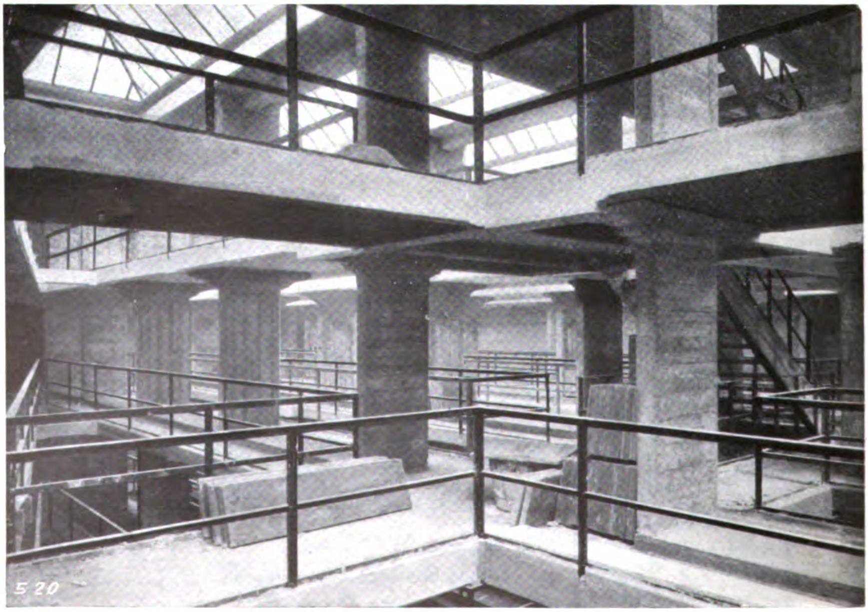
THE Depôt which was recently constructed at Lille for the storage and classification of the documents of one of the Government Departments is a striking example of the advantages of reinforced concrete for practical and economical purposes.



General view of galleries.
DEPOT FOR GOVERNMENT ARCHIVES AT LILLE.

One of the most important points to be considered in its erection was the elimination of all fire risks from the outside, as the depôt is surrounded on all sides by the high party walls of the adjoining buildings. For this reason reinforced concrete was used on





View of galleries nearing completion.

DEPOT FOR GOVERNMENT ARCHIVES AT LILLE.

account of its well-known fire-resisting qualities, and by its use the maximum amount of storage capacity was also obtained.

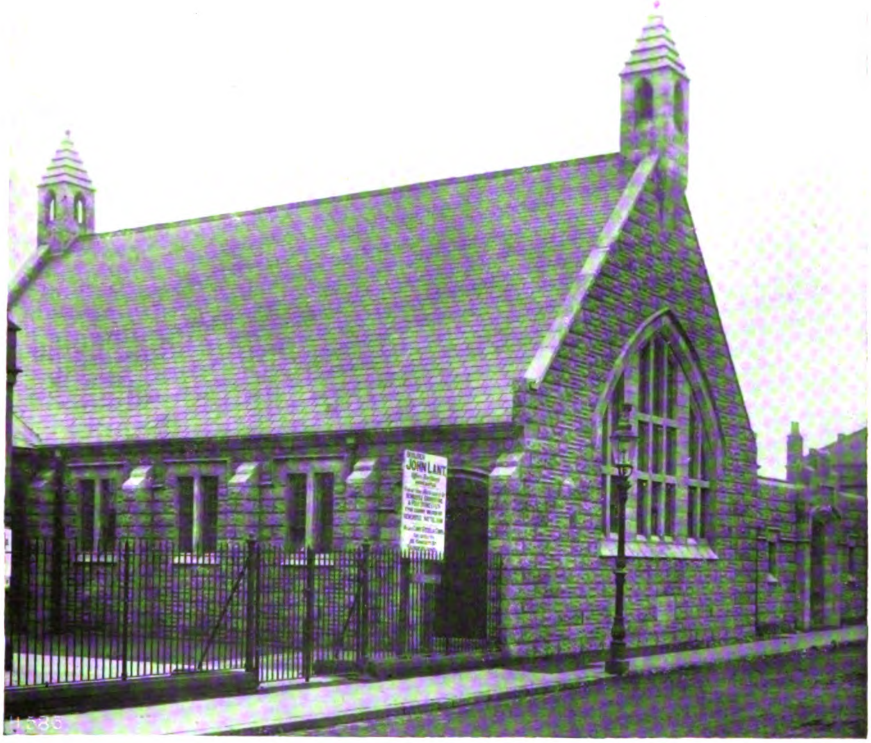
There are four storeys, each containing five galleries, supported by concrete columns from the foundations to the terrace on top. Each gallery is about 8 ft. 2 in. between the uprights.

The reinforced concrete staircases are open, and are composed of two strings with concrete treads, without risers. The terrace, which is covered with asphalt and coke breeze, contains the skylights for the galleries.

The whole structure was carried out in reinforced concrete on the Hennebique system, and it has given great satisfaction to all concerned.

The architect was M. L. Hainez, Chief Architect of the Département du Nord, the contractor being M. C. Debosque-Bonte, of Armentières.

We are indebted to the *Béton Armé* for the illustrations on page 600; that on page 599 was placed at our disposal by *The Builder*.



Parochial Hall, Wallsend-on-Tyne.

PAROCHIAL HALL, WALLSEND-ON-TYNE, BUILT OF CONCRETE BLOCKS.

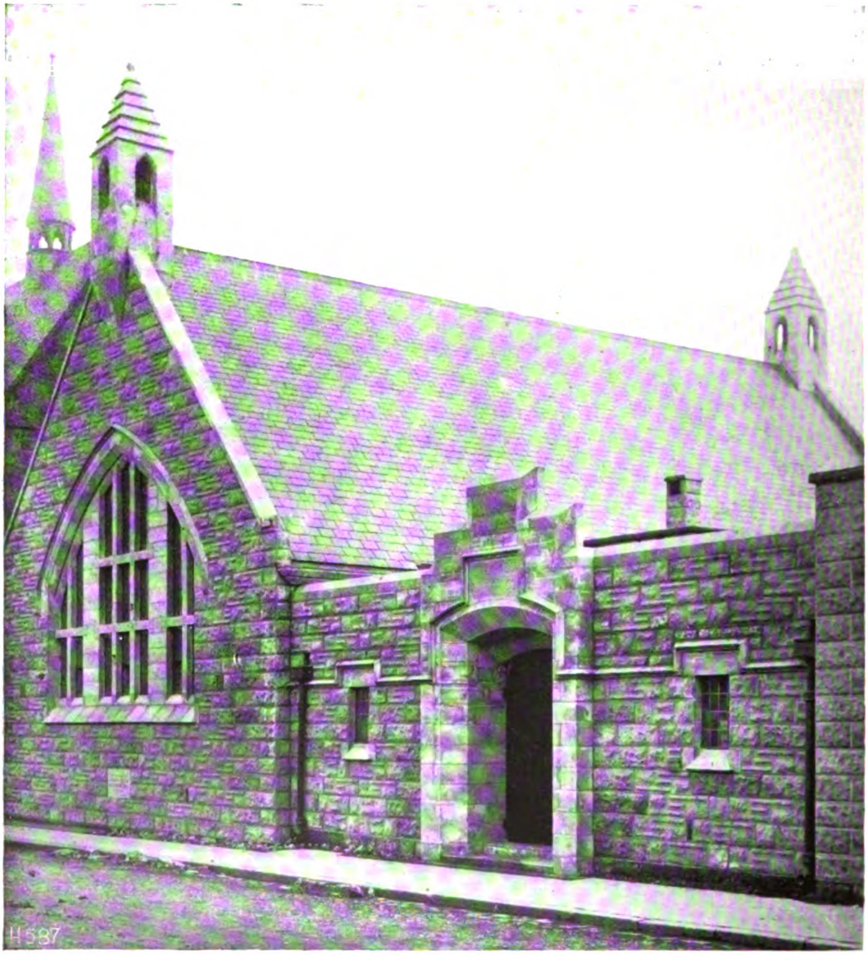
We have dealt very frequently in our pages with the advantages of concrete blocks for building purposes, pointing out the ease and rapidity with which such buildings are erected.

We have shown cottages, bungalows, schools, etc., erected of concrete blocks, while on the present occasion we are giving illustrations on pages 601 and 602 of a parochial hall at Wallsend-on-Tyne.

This hall was built of concrete blocks manufactured by the Newcastle Grindstone & Pulpstone Co., Ltd., on the "Winget" machine, the proprietors of which are the

U.K. Winget Concrete Machine Co., of Newcastle-on-Tyne. The contractor for the work was Mr. John Lant, of Newcastle-on-Tyne, the contract price being approximately £1,700.

The blocks in this building are 9-in. thick, with 3½-in. cove holes, and, as will be seen from the illustrations, the blocks are made to resemble broken ashlar work.



Another View of Parochial Hall, Wallsend-on-Tyne.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE IN MINES.

WE have drawn attention on various occasions in our journal to the great advantages which are to be derived from the use of reinforced concrete structures in mines, and we are illustrating in this article some very important works which have been executed in this new material for various well-known mines in the north of France.

The works shown were carried out on the Coignet system, and they are a very good example of the manner in which it is possible to substitute reinforced concrete for steel construction.

Fig. 1 shows a large refrigerator constructed in reinforced concrete on the Coignet system for the "Société des Mines de Lens." This is another new application of reinforced concrete, and it is quite obvious that this material is exceedingly well adapted for this purpose. It offers the great advantage that it cannot decay like wood or corrode like steel.

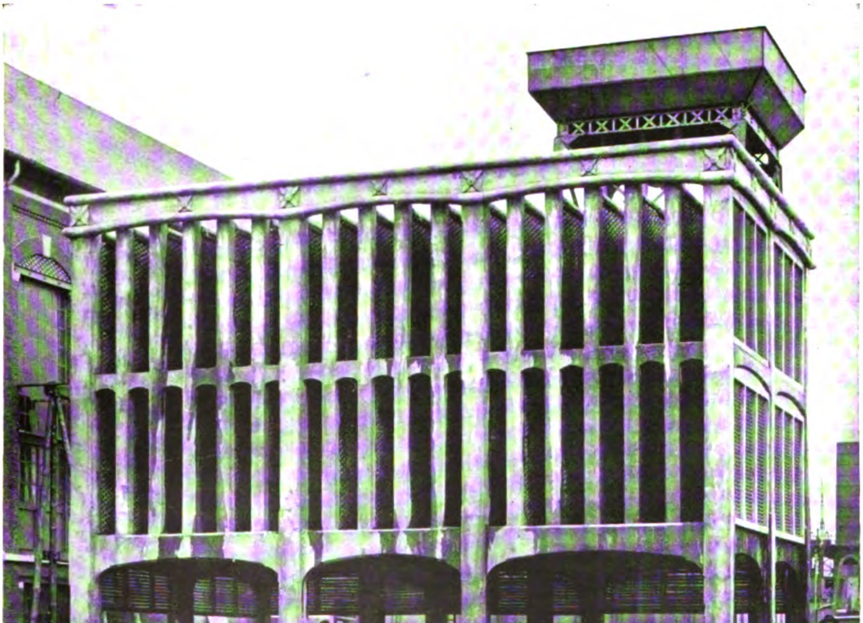


FIG. 1. REINFORCED CONCRETE REFRIGERATOR FOR THE SOCIETE DES MINES DE LENS.

Fig. 2 gives a bird's-eye view of the various gantries, bunkers, and pithead structures executed for the "Compagnie des Mines de Houille de Marles" (Pas de Calais).

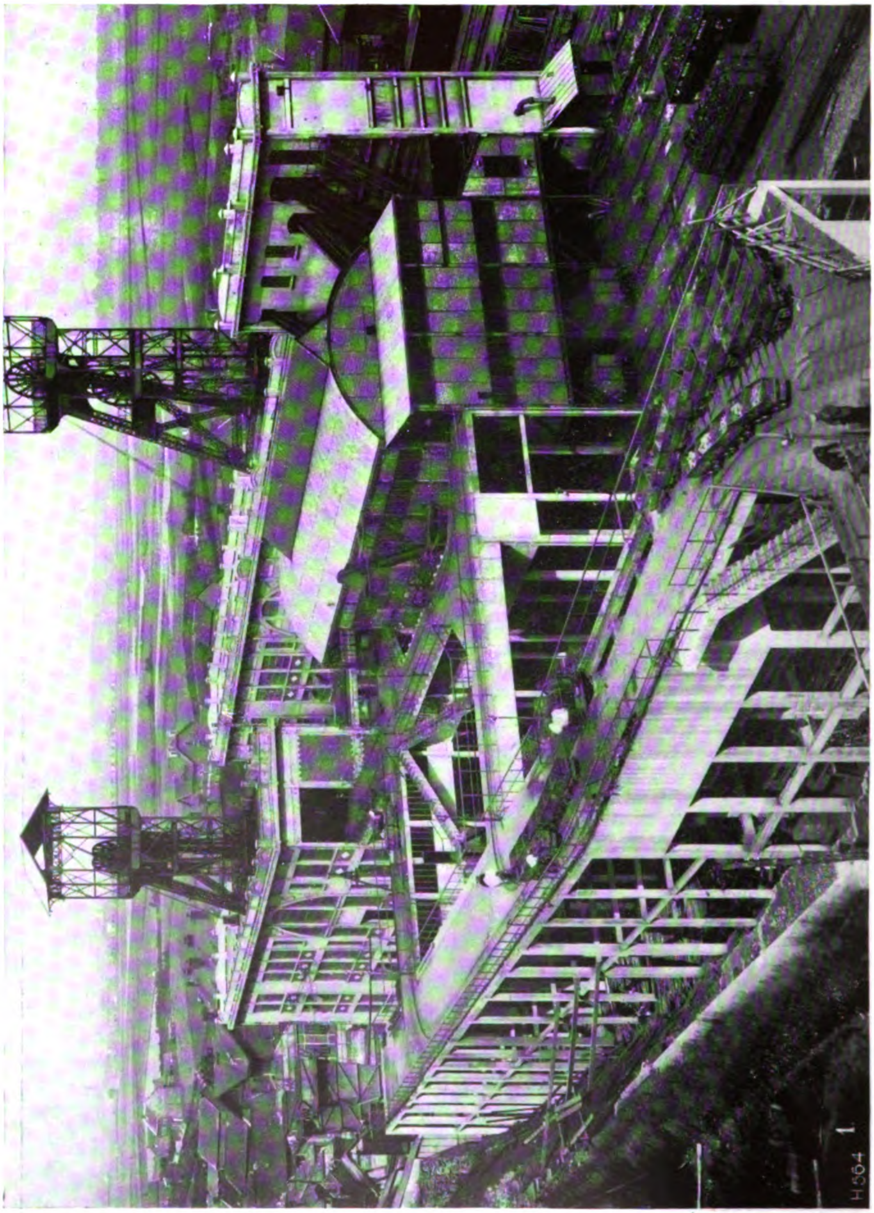


Fig. 2. Gantries, bunkers and pithead structures.

Reinforced Concrete Structures executed for the Compagnie des Mines de Houille de Marles.

It will be noticed that these buildings have a very pleasing effect, and are far from having the gloomy appearance which characterises most of our mining structures. In fact, the buildings surrounding the shafts have been decorated with tiles and coloured brickwork. It will also be observed that the reinforced concrete compares very favourably in aspect with the old steel and brick building, which will be seen in the centre of the photograph. The high building on the right-hand side contains various bunkers in reinforced concrete.

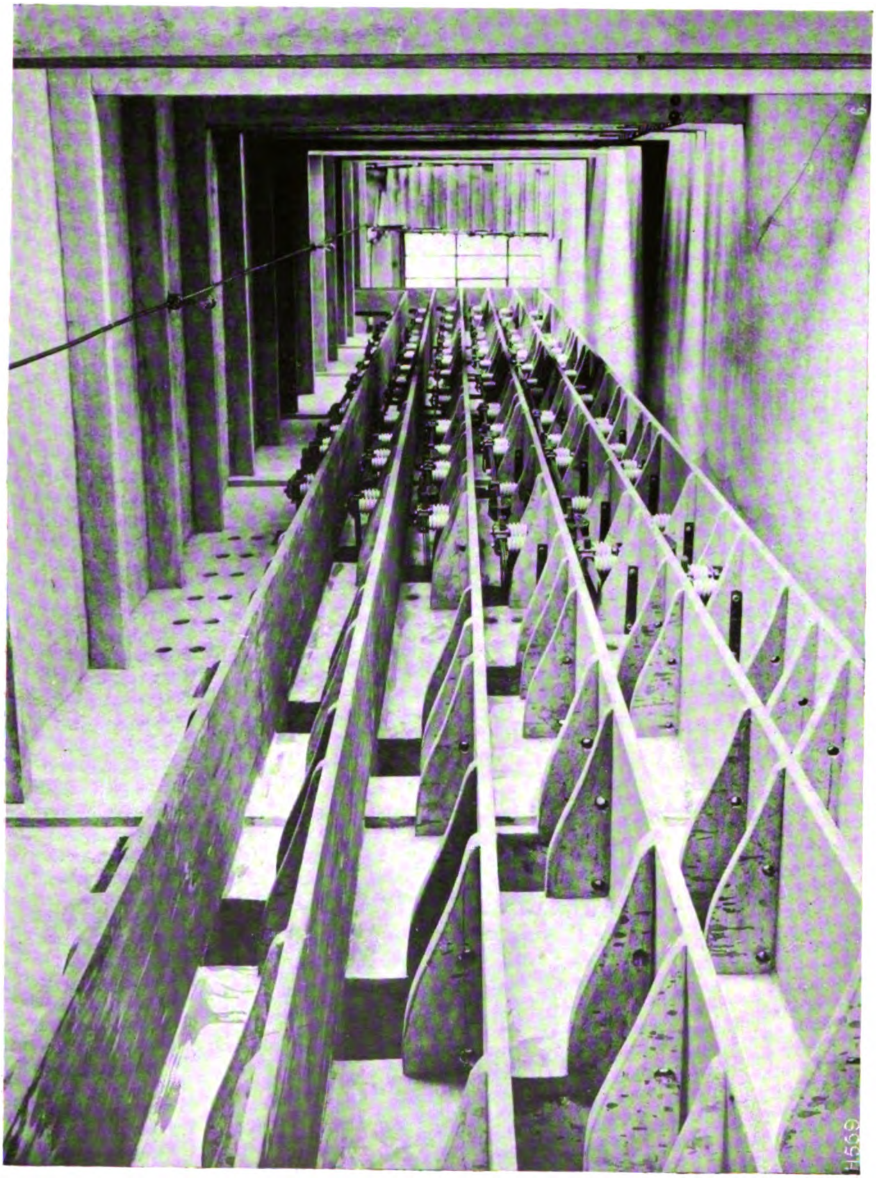


Fig. 3. Reinforced concrete shelves and switchboards.
Reinforced Concrete Work for the Compagnie des Mines de Houille de Marles.

Fig. 3 shows a series of reinforced concrete shelves and switchboards for the distribution of electric current at the above mines.

Photo No. 4 shows two earth silos, which form part of the work above described.

These are placed underneath the gantry, and the openings giving access into these will be noticed by looking at the general illustration on page 604.

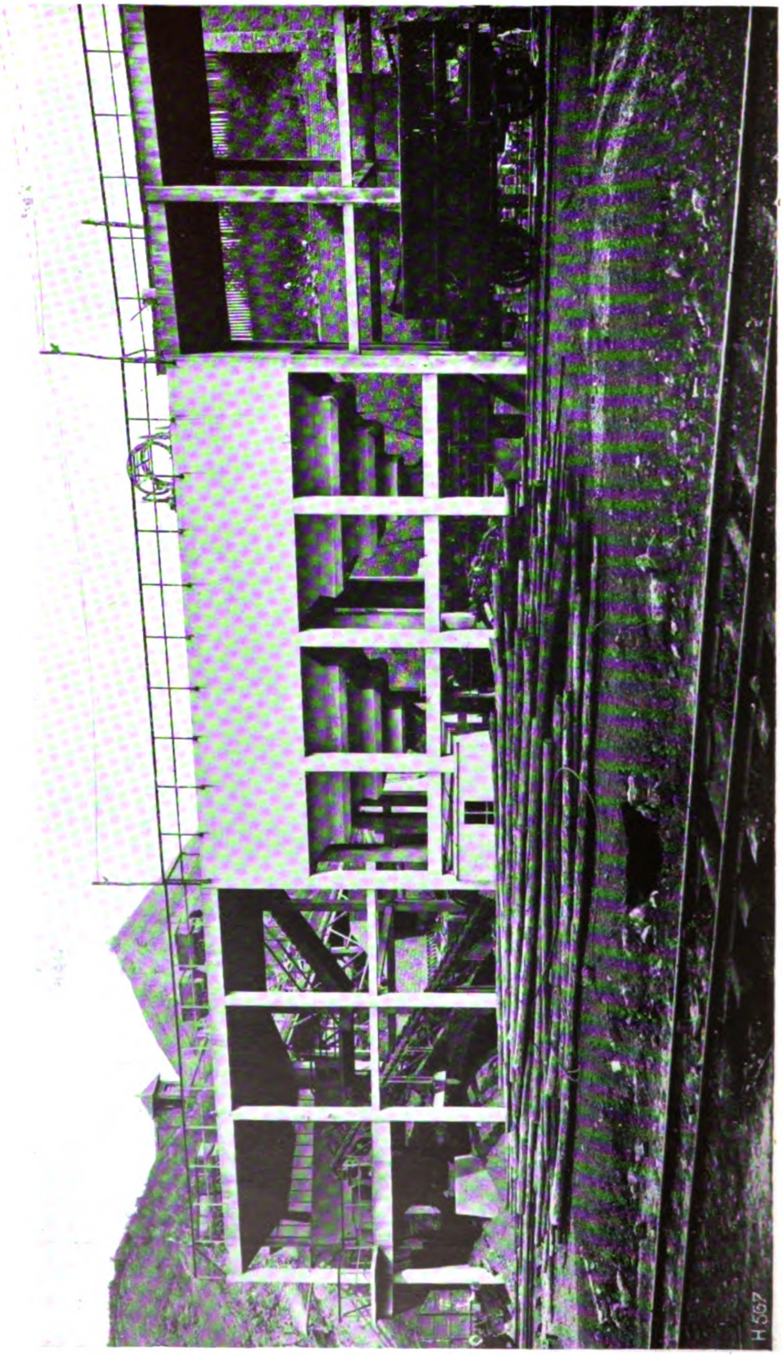


Fig. 4 Reinforced Concrete Silos for the Compagnie des Mines de Houille de Marles.

An inclined plane was also erected in reinforced concrete for the same company. This is illustrated in No. 5. The total length of the plane is approximately 30 metres, with a width of 5 metres. The platform is at a height of 17 metres above the foundations, and measures 100 sq. metres in area. As will be noticed in the photo, it is covered with a flat roof in reinforced concrete.

We had the opportunity of describing, several months ago, a pithead structure which was carried out on the Coignet system of reinforced concrete for the same company, the object of this structure being to suspend a new shaft weighing 200 tons, which had to be constructed upon very inconsistent ground. The above-mentioned company has, during the last few years, employed reinforced concrete almost exclusively for a large variety of works, and we are informed that all these have proved very satisfactory.

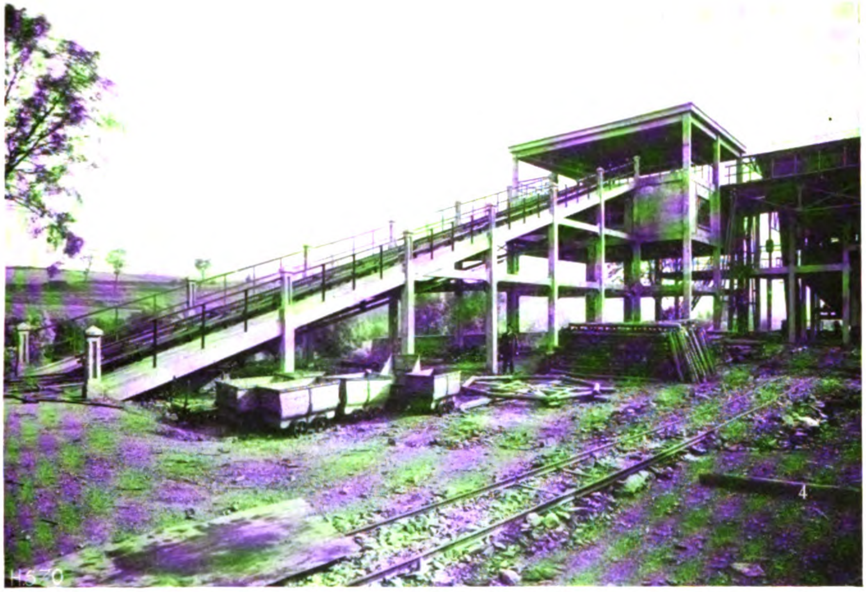


Fig. 5. Inclined Plane made of Reinforced Concrete.

The illustrations should go far to convince British mining companies of the excellency of reinforced concrete as applied to mines.

We are indebted to Messrs. Edmond Coignet, Ltd., for the illustrations and description of these works.

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favcur of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

CONCRETE MACHINERY.

CONCRETE BRICK MACHINES.

CONCRETE bricks are almost unknown in this country in spite of the fact that in the few places where they are manufactured there is always a ready market for them. There can be no doubt, however, that, as in the case with the hollow building blocks, their use will soon become much more general, and they will be manufactured everywhere, for there can be no reasonable objection to them. Hollow blocks are suitable in most cases, but there are times when the large block will not do, but the concrete brick will.

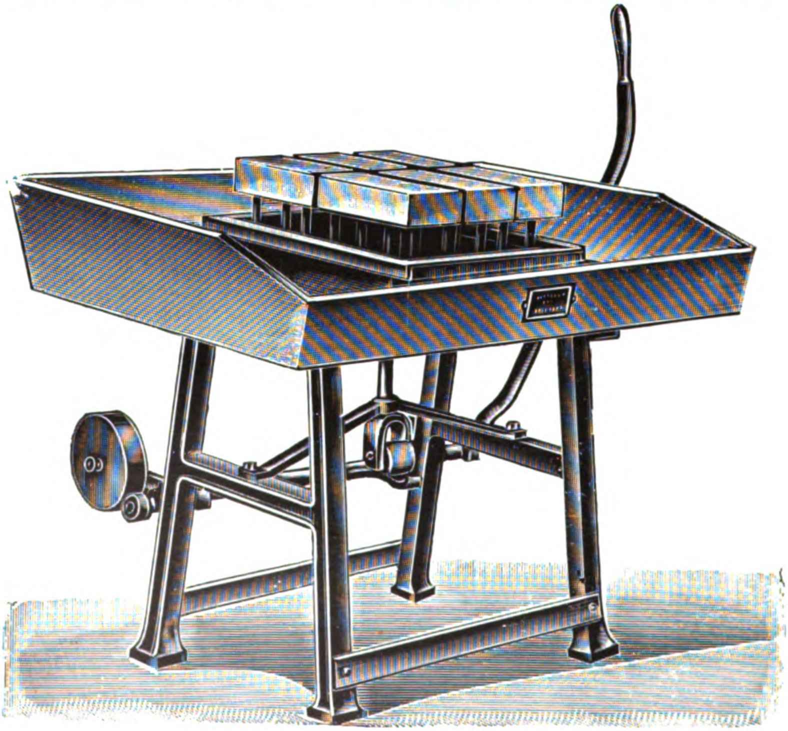


FIG. 1. MACHINE FOR MAKING CONCRETE BRICKS.

The following are some of the principal advantages which concrete bricks possess as compared with those made of clay :

The edges of the concrete brick are always sharp, and the brick is itself regular and perfectly straight, one being exactly like the other. Further, concrete brick is not nearly so absorbent as clay brick, and the possibility of giving it any colour is an advantage which ought not to be overlooked.

The bricks are made in two different ways: on presses and on tamping machines. Presses worked by hand or hydraulic power are not advisable, for by this process the mortar has to be almost dry, causing the bricks to become porous, and the cost of production becomes rather expensive. On the other hand, with tamping machines worked by hand the mortar may be fairly wet, and through the high output the cost of production is greatly lessened.

The First Cottbus Cement Goods and Machine Works, besides several other brick machines, manufacture that illustrated in *Fig.* 1. On it one man, without any assistance, turns out 3,000 bricks a day, the mortar, of course, having to be provided. Full, hollow, key, and moulded bricks and paving slabs can be made on the same machine. The manufacture is very simple, the mortar being tamped into the mould-box and the lever turned, thus releasing the finished bricks, which are then put into racks to harden. After two days the bricks are ready for stacking, and after six weeks they can be used for building purposes.

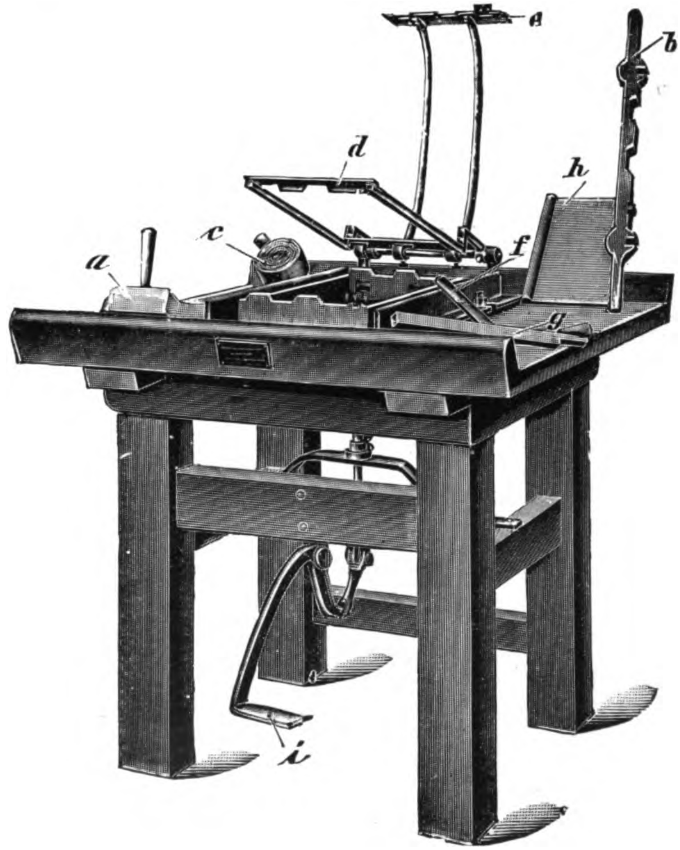


FIG. 2. CONCRETE ROOFING TILE MACHINE.

CONCRETE ROOFING TILES.

In the United States and the Continent concrete roofing tiles are used everywhere. There are many different types on the market, most of them being interlocking.

The concrete interlocking roofing tile has really so many advantages that one cannot understand why it should have been neglected so long over here. By the processes which it undergoes during its manufacture the concrete roofing tile is made absolutely impervious, and will stand any test in this respect.

It provides a much lighter roof, for, while a square (100 sq. ft.) of slate roofing weighs on an average $10\frac{1}{2}$ cwt., and the clay tile roofing 15 cwt., a square of concrete tile roofing only weighs 7 cwt.

While clay tiles always become more or less warped through the process of burning, concrete tiles are perfectly true, thus their locks must always fit exactly, and they provide a roof which will resist any storm.

Their manufacture is quite simple and can be thoroughly learned by any workman in a few hours.

On the machine in *Fig.* 2 one man can turn out 1,200 to 1,500 tiles per week if he has to do all the work connected with it, such as mixing the mortar, stacking the tiles in the yard, moistening them, etc.

The cost of production is very moderate, and if, in spite of their superiority, they are sold at the price of clay tiles, the net profit on them is still immense.

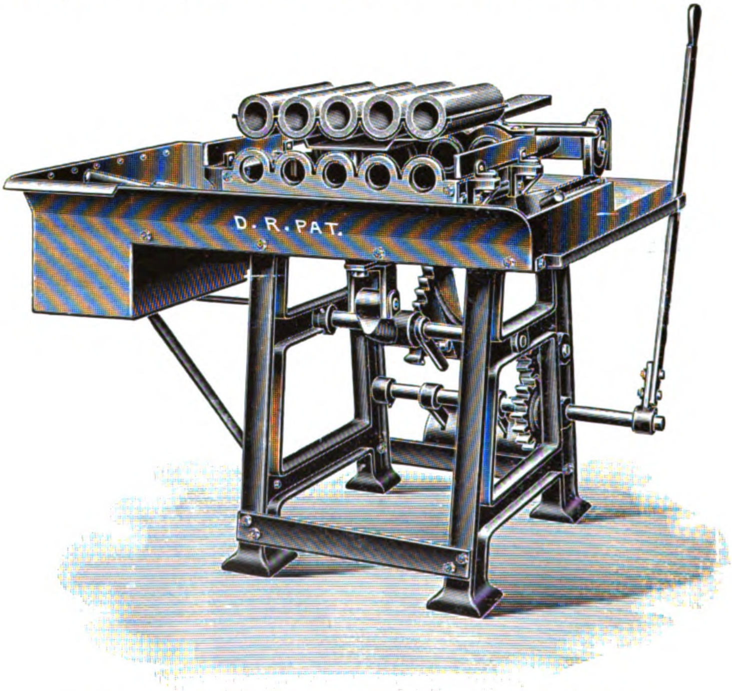


FIG. 3. MACHINE FOR MANUFACTURING CONCRETE AGRICULTURAL PIPES.

CONCRETE AGRICULTURAL PIPES.

CONCRETE has been found to be very suitable for making agricultural pipes. In the United States, the Colonies and abroad they are manufactured to a very large extent, with very satisfactory results. If properly made these pipes are porous, which is one of the principal requirements. For this purpose it is necessary to make the mortar damp, but not wet. Sand of regular grain must be used, and when seasoning the pipes they should be sprinkled as little as possible. Pipes made in this way will take in water their whole length, which is not the case with clay pipes, where the water comes in at the joints only.

Concrete agricultural pipes become harder the longer they are in the ground, while those made of clay depreciate in value year by year, and after thirty years at least, must be renewed.

Some may have another objection and say that clay pipes are put on the market at such a low price that it would be impossible for the manufacturer of concrete pipes to compete with the makers of clay pipes. These pipes can be manufactured at a very low price. 1,000 pipes can be turned out in a day by one man on the machine shown in *Fig.* 3, and the cost of production therefore is very low. On this machine several pipes are made at a time, and pipes with a diameter from 1½ in. up to 6 in. can be made on it. The process of manufacture is very simple, and any workman will be able to reach the given output of 1,000 pipes per day after the second or third day.

The greatest advantage for the concrete goods mentioned in this article is that manufacture does not require a large plant for working with power, but anybody who has the proper material at his disposal, by employing one or two men, can turn out a considerable quantity of goods per annum which are in great demand by the building trade.

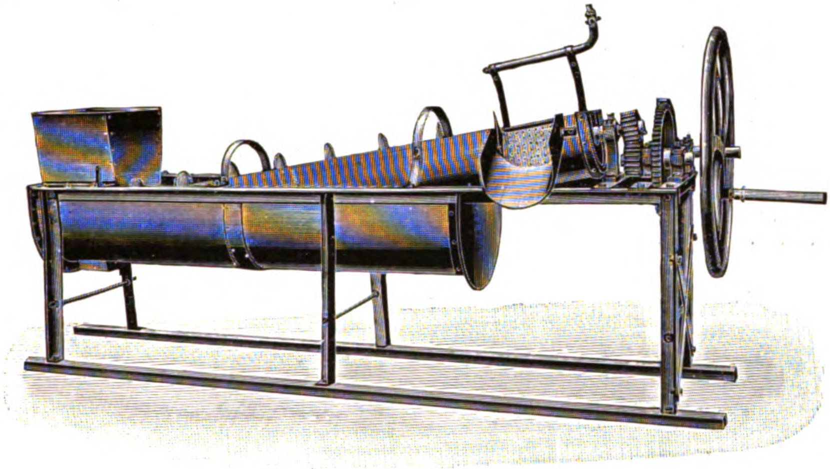


FIG. 4. SAND AND GRAVEL WASHER.

SAND AND GRAVEL SIFTING AND SORTING MACHINE.

THE outcome of a long-felt necessity in the concrete business is the sand and gravel sifting and sorting machine, turned out by The First Cottbus Cement Goods and Machine Works.

It is built for working by hand or power and runs very easily.

At one sifting the gravel, as well as the residue, can be obtained in six different sizes of grain. Each kind is obtained separately and can be emptied straight into its own tipping wagon or hand tip-cart, which can be rolled under the corresponding part of the sifting machine. On the Continent it has won many friends, which no doubt will be the case over here.

SAND AND GRAVEL WASHERS.

THIS washer, shown in *Fig.* 4, has been constructed on the following principle: While the water flows downwards, the sand, gravel, etc., travel upwards, and after being turned over repeatedly by the mixing screw it arrives at the upper end thoroughly clean, while the dirty water is discharged at the lower end.

For concrete manufacturers who have to deal with dirty material this machine, which is simple and strong in its construction, is a great help and enables them to turn out a good clean product.

The representative of The First Cottbus Cement Goods and Machine Works, Mr. R. H. Baumgarten, 1 Laleham Road, Catford, London, S.E., is always pleased to receive applications from interested readers to see the machines at work in London, and to supply fullest particulars of the machines which this firm manufactures.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the past year.

"Reinforced Concrete." By Captain J. G. Fleming, R.E.

Published by the Royal Engineers' Institute, Chatham. Price 3/6 net.

Contents. — Introductory. — Loads and Working Stresses.—Moments of Resistance of Rectangular Beams.—Deflection. — Shear. — Slabs. — T Beams.—Columns, Pipes, Reservoirs, Arches, Domes.—Materials, Centering.—Erection.—Examples of the Application of Reinforced Concrete.

This book is well described by Lieut.-Col. J. Winn in a preface he has contributed, in which he says: "In this book . . . . . we have condensed into a convenient compass a mass of practical information, which should enable anyone confronted with the task of designing and erecting reinforced concrete structures to tackle the subject with confidence and ease. The author has hit upon the happy mean between a mere sketch and a ponderous work, which wearies rather than enlightens. Designed primarily for the use of practical men, it contains enough detail to satisfy the needs of such without being overloaded with needless dissertations on abstract points, which may never arise, or cumbrous calculations difficult to apply."

Capt. Fleming has certainly produced a handy summary of the subject, which will be very useful to others than his brother Royal Engineers. The work contains various graphs to aid in designing, but we must say that they are not quite so ready a means of designing as we could wish, nor as could have been drawn up. The formulæ for beams are still too cumbersome to employ in practical work, though, of course, it is desirable to have the correct ones on record, but they can be used to draft graphs which are more of use to the designer.

The notation employed is not very handy, and we are sorry that Capt. Fleming did not use that advocated by the Concrete Institute. The information about arches is meagre, while that on domes is reproduced from Messrs. Marsh & Dunn's work, without alteration in the letterpress, too, which was necessary, in view of the illustrations being retitled, so that it is not quite clear to follow. However, the book is commendable as an introduction to the subject.

"Principles of Reinforced Concrete Construction." By F. E. Turneaure, *Dean of College of Engineering, University of Wisconsin, and* **E. R. Maurer,** *Professor of Mathematics, University of Wisconsin.*

Second Edition. London: Chapman & Hall, Ltd; New York: John Wiley & Sons. Price 14/6, or $3.50.

Contents.—Introductory.—Properties of the Material.—General Theory.—Tests of Beams and Columns.—Working Stresses and General Constructive Details.—Formulas, Diagrams, and Tables.—Building Construction.—Arches.—Retaining Walls and Dams — Miscellaneous Structures.—Reinforced Concrete Chimneys.

This is one of the best books on the subject that have been published, and this second edition is a great improvement on the first. The subject of shear stresses and diagonal reinforcement is well dealt with, and both this and the subject of arches and tall chimneys have been extended in treatment in this edition. There are many graphs and tables included which will be of service to the designers; and, altogether, the work is one which ought to be purchased by every student of the subject.

"How to Use Concrete." Compiled by Walter C. Boynton and R. Marshall.

Published by Concrete Publishing Co., Detroit, Mich. Price not stated.

Contents.—Moulding Monolithic Concrete Balustrades.—How to Make a Seaworthy Concrete Boat.—Bridge Work, Balustrades and Ornamentation Plaster Face-Plates for Monolithic Wall.—How to Make a Plant Urn.—Building a Concrete Block Furnace.—Concrete Bath and Laundry Tubs.—Moulding Ornamental Flower Pots and Vases.—Reinforced Concrete Benches for Greenhouses.—Laying Wood Floors on Concrete Bases.—Concrete Mantel and Fireplace.—Silos, Stand Pipes, and

Water Towers.—Concrete Tanks for Feed Water Storage.—Model Concrete Tile Plant.—Cost of Concrete Culvert. — Concrete Linings for Ditches.—Cost of Concrete Drain Tile. — How to Mould Concrete Benches.—Concrete Arbour Seat of Simple Design.—Making Hexagonal Sidewalk Block in Concrete.—Concrete Pavement in Fond du Lac, Wisconsin.—Concrete Pavements under Patents.—Material Required for Concrete Sidewalks.—Cost Figures on Concrete Sidewalks.—Wire Conduits made of Concrete.—Concrete Gutter Covers at Cross Walks.—Associations of Cement Users.—Concrete Bridges of Simple Design.—Concrete Theatres, Banks, and Schools.—How to Make Concrete Monuments. —Glue and Waste Moulds for Concrete Work.—Moulding Ornamental Concrete Work. — Concrete Block Cost Data.—Stucco, What it Is, and How Applied.—Strength of Concrete Brick. — Manufacture of Concrete Fence Posts.—N.A.C.U. Sidewalk Specifications.—Miscellaneous Information.

This book is a collection of information mostly published in our American contemporary *Concrete*, and is written in a plain homely way for the lay user (if he may be so called), and concerns itself with work specially of interest to him. At the same time it is instructive to the ordinary smaller manufacturer of artificial stone. The farmer and the builder in country districts will find it specially valuable. It is almost of the nature of a collection of recipes for concrete work.

"Concrete: Its Composition and Use." By H. F. Porter and others.

Published by *Concrete Engineering* Cleveland, U.S.A. Price $2.

Contents.—Lime, Puzzolano, and Natural Cement.—Portland Cement.—Balancing of the Compounds and Calculation of the Mix.—Manufacture of Portland Cement.—Laboratory Work. —Materials of Construction.—Concrete.—An Analysis of the Action of Cement.—The Use of Mineral Oil in Concrete.

This book is intended to present, in a direct way, the underlying facts and best present-day practice in concrete making. And it certainly does that very clearly. It is concerned with the analysis and manufacture of the materials, and the making of concrete, and it gives a very extensive amount of information that is not to be found collected in this way in other works on the subjects of concrete. Much is new information, and interesting attempts, explaining scientifically the various phenomena connected with the materials and manufacture of concrete.

TWO ITALIAN BOOKS ON REINFORCED CONCRETE.

Le prove dei materiali da costruzione e le costruzioni in cemento armato. (The Testing of Structural Materials and Construction in Reinforced Concrete). By Professor G. Revere.

Published by Ulrico Hoepli, Milan, 1910.

Il Cemento Armato e la sua Applicazione Practica. (Reinforced Concrete and its Practical Applications.) By C. Pesenti.

Published by Ulrico Hoepli, Milan, 1910.

These two works, issued by the well-known firm of publishers in Milan, afford striking evidence of the attention devoted by Italian engineers to the applications of reinforced concrete, and to the scientific study of its properties.

The first, and larger, work is from the pen of the editor of the journal *Il Cemento*, and is divided into two parts, dealing respectively with the methods of testing structural materials, and with construction in reinforced concrete. The first section is an admirably clear and concise account of testing methods, including a highly interesting historical review of the subject. The author is well acquainted with the technical literature of other European countries, and gives very full references, in which we have only noted a few slight errors. Each chapter is followed by the Italian Ministerial regulations for the testing of the corresponding materials, which may be usefully compared with those in force in this country and elsewhere. The conclusions of the Copenhagen Congress, of 1909, have been taken into account in the discussions of the more important materials. The methods of testing cement and concrete, described by the author, follow the usual lines, but hydraulic lime and puzzolano receive rather fuller treatment than in most works of the kind. The testing of concrete pipes is also included. On the whole, this is, perhaps, the most satisfactory introduction to the subject of testing at present available.

The second section presents less novelty, as excellent treatises on reinforced concrete are now available in English, French and German. A clear account is given of the principal system of construction, of the methods of calculating stresses and dimensioning structures, and of some important recent examples of this type of structure. The latter are mainly, but not entirely, selected from Italian examples, some of which, including several important bridges, have been recently described in our journal.

The second work is on a smaller scale, and has a more limited scope. It contains a clear account of the methods of calculation in dealing with reinforced concrete structures, without reference to any special systems, accompanied by tables and by diagrams (printed on accurately squared paper) for the graphical computation of the stresses. The application of the formulæ and graphical methods to practical examples is fully described, and the treatment of the subject is throughout concise, so that an engineer called upon to determine the dimensions of a structure in reinforced concrete will find the information which he requires without difficulty, illustrated by worked numerical examples. The methods of calculating the cost of reinforced concrete work are also explained.

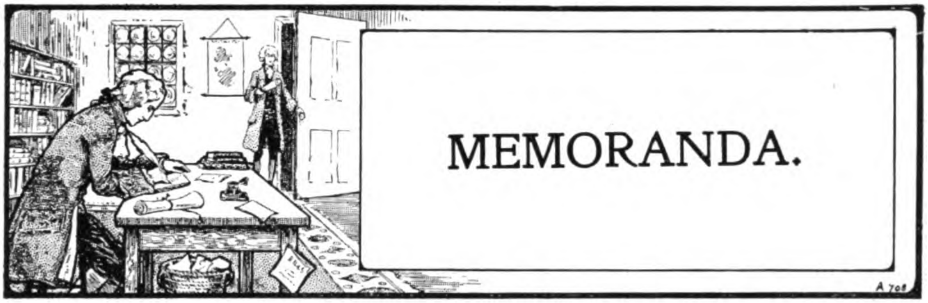
Both books are excellently printed and illustrated.

"Reinforced Concrete Construction." By W. Noble Twelvetrees, M.I.Mech.E.

Published by *The Local Government Officer*, Whitefriars Street, London. Price 1/- net.

Contents. — Theory of Beams and Columns.—Formulæ for Beams.—Formulæ for Columns.—Practical Construction.

This pamphlet gives in 40 small pages a useful summary of the principles of reinforced concrete design, together with a number of notes on practical construction. Naturally, in such a small compass it is only possible to touch the fringe of the subject, but, certainly, Mr. Twelvetrees has performed his task well. He is to be commended for endeavouring to secure an easily understood notation for his calculations, but he would be better advised to adopt the Concrete Institute's Standard Notation. Mr. Twelvetrees advocates the adoption of 500 lbs. per sq. in. as the working stress for 1 : 2 : 4 concrete in compression at the age of one month, and 700 lbs. at six months, and 400 lbs. per sq. in. for 1 : 3 : 6 at one month, and 550 at six months. He likewise varies the safe stress in tension, shear, and the co-efficient of elasticity. The steel, he suggests, should be taken at 15,000 lbs. per sq. in. in tension. Now, these values may be argued for and against, though they seem quite reasonable from certain points of view, and considering that this book is only a short summary, and too much latitude is unwise in instructing the elementary student, we think it would have been better to adhere to the R.I.B.A. report, and adopt 600 lbs. per sq. in. as the compressive resistance of concrete in beams, 500 lbs. per sq. in. in columns, 16,000 lbs. per sq. in. steel in tension, and 15 for the modular ratio. The derivation of the formulæ given is not explained, and as they are not abbreviated, nor put in graphical form for practical use, they are of little service for designing, and only obscure the mind of the student. In short, the book tends to be too advanced at some points, while at others it is very elementary. It should have been uniformly elementary. Still, it it is commendable, on the whole.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

THE CHINGFORD RESERVOIR.

Visit of the Concrete Institute to Chingford.—By the courtesy of Mr. William B. Bryan, M.Inst.C.E., Chief Engineer of the Metropolitan Water Board, some members of the Concrete Institute visited the new Chingford Reservoir Works on Wednesday, June 29. The party assembled at Enfield Lock Station and were conducted over the works by Mr. Charles F. Marsh, M.Inst.C.E., and Mr. T. C. Deverell, M.Inst.C.E.

The Chingford Reservoir—the reinforced concrete bridges in connection therewith were described in our issue of January last—will contain about 3,000 million gallons. The water area is 416 acres, and the length of embankment about 4½ miles.

The general description of the works issued by the Institute reads as follows:

" The embankment is being formed of material excavated from within the reservoir. The top portion of the inner slope will be lined with concrete, and this for a distance of 4 ft. below top water will be faced with brickwork. The lining will consist of a brick-faced vertical wall 3 ft. high, with concrete coping, which will be rounded off at the bottom to meet the lower portion of the lining which is formed on the slope.

" The water will be pumped into the reservoir from the River Lee and River Lee Navigation at the north end through five lines of 48-in. cast-iron pipes passing up the outer slope and discharging into a chamber at the top of the embankment. From this chamber the water will pass over a long granite sill down an inclined slope into a stepped channel.

" The outlet from the reservoir will be at the south-east corner. The valve houses on the outlet shafts will be constructed of concrete and have domed roofs. The inner shaft will be connected to the reservoir embankment by a reinforced concrete bridge 6 ft. wide between parapets and 20 ft. span. The parapets of this bridge will be reinforced to act as girders supporting the decking.

" From the outer shaft the water will pass through a line of 36-in. pipes to a chamber controlled by an automatic valve on the south side of Marsh Lane. From this chamber an outlet channel conducts the water for a distance of about 2 miles to an existing basin, from whence it can be passed to the other reservoirs of the Metropolitan Water Board's Eastern District, and thence to the filter beds of Lee Bridge. From the outer shaft of the reservoir there will be a further line of 36-in. scour pipes discharging into the River Lee Diversion.

" The construction of the reservoir necessitates several considerable subservient works. The River Lee has been diverted for a distance of 3 miles through a channel 55 ft. wide with side walls of concrete faced with Kentish rag stone and coped with concrete blocks.

" Intake channels are also in course of construction from the River Lee and River Lee Navigation to the site of the pumping station at the northern end of the reservoir.

" A channel 3½ miles long has been constructed along the eastern side of the works to divert the contaminated water from the hillside, and discharge this below Flander's Weir into the old river channel.

" An overflow weir has been constructed to pass flood waters from the Lee

Navigation, discharging into the old River Lee below the reservoir. The public road crosses the channel on a concrete bridge. The towing path crosses the overflow weir on a reinforced concrete bridge; it also crosses the weir, supplying water to the pumps from the Lee Navigation by a similar bridge. (*See January issue, 1910.*)

"The Lee Valley road has been diverted for a length of 1,000 yards, the surface of the diverted portion being of tar-macadam.

"The intake channel from the River Lee and the River Lee Diversion are crossed by five reinforced concrete arched bridges, one of which—that carrying the public road over the Lee Diversion—has three spans of 27½ ft. with 5ft. rise, and will be on the skew. The other bridges have single spans, one of 50 ft. and the other three of 55 ft., the rise in all cases being 5½ ft. The width of the public road bridge will be 40 ft. between parapets, and that of the other bridges 12 ft. between parapets. One of the 55-ft. span bridges is for foot traffic only, being of a different design and only 6 ft. wide between parapets."

View of Part of British Improved Construction Co.'s Works, Fulham.

VISIT TO THE BRITISH IMPROVED CONSTRUCTION COMPANY'S WORKS AT FULHAM.

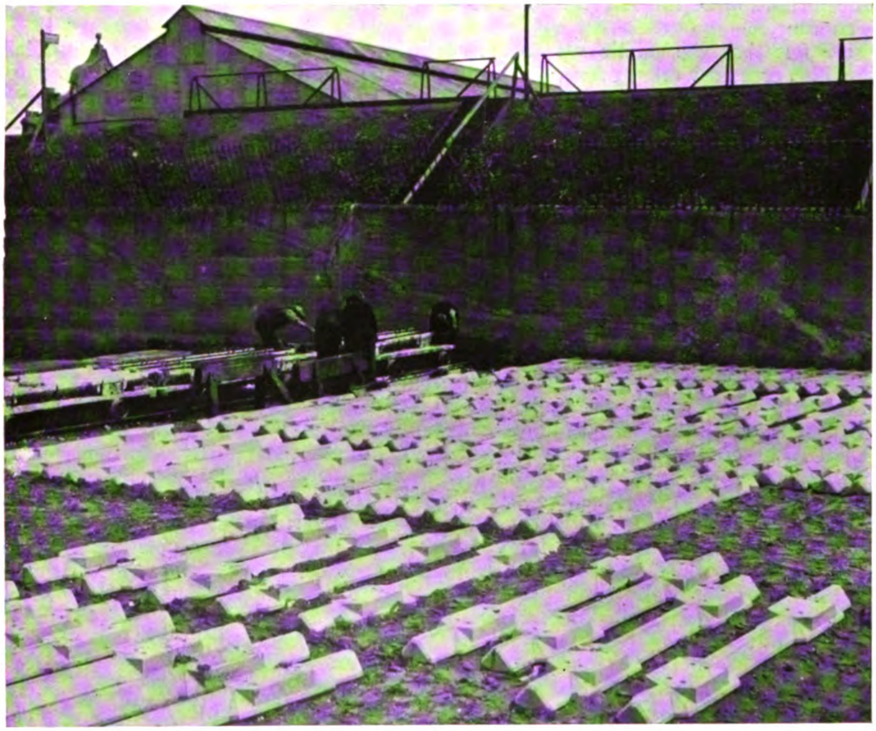
On Saturday, July 23rd, at the invitation of the directors of the British Improved Construction Co., Ltd., a party of the members of the Concrete Institute paid a visit to the Company's works at Fulham. The guests were received by Mr. Alec Matheson, the Chairman of the Company, till recently a member of the Australian Senate, and were shown over the works and grounds by Mr. Jagger, the inventor of the process, and Mr. Livingstone, the Company's Engineer.

These up-to-date works have just been completed for the construction of all kinds of concrete and reinforced concrete by the Jagger process. They have been built with a view of economising labour in every direction, and securing as far as possible the automatic passage of the material from the mixer to the hot-air chamber, in which all products receive final treatment for 24 hours before being turned out in the yard.

We may mention that this company are using two "Ransome" Concrete Mixers, each having a batch of 20 cu. ft., and a guaranteed output of 200 cu. yds. per day, supplied by the Ransome ver Mehr Machinery Company.

The visitors were shown the complete process of manufacturing concrete pipes. They saw the cement and granite placed in the mixer and the resultant concrete delivered into the moulds on the Jagger table; five minutes later the pipe moulds were whisked off the table and others took their place, while the completed pipes were quickly rolled into the hot-air chamber. An interesting feature was the exhibition of a reinforced and an unreinforced pipe being made side by side, during which it was realised that the one is made as quickly as the other by the Jagger processes, the only difference being the time required to weave and place the reinforcement.

The complete process of construction of reinforced railway sleepers was also shown; the wires being cut, straightened, twisted and bent by a series of rather elaborate machines, the various parts being threaded together by boys, placed in the moulds, and finally covered with the concrete at the rate of 28 an hour. Various interesting tests applied to the completed sleepers were given.



Reinforced Concrete Sleepers at the British Improved Construction Co.'s Works, Fulham.

The manner in which the company's partition slabs are cast in trolley moulds was explained; the trolleys were rolled on the table, shaken up and rolled off again at the rate of 100 yds. per hour.

Tea was served in the pavilion. A hearty vote of thanks, proposed by Mr. W. G. Kirkaldy, A.M.Inst.C.E., and seconded by Mr. J. Wager (late of H.M. Office of Works), was passed to the company. Mr. Matheson made a short speech in reply.

Association of Consulting Engineers.—On July 13th a meeting, presided over by Sir William Preece, K.C.B., F.R.S., was held at Caxton Hall to consider the desirability of forming an Association of Consulting Engineers, the object of the Association being to improve the status of the profession and to place it on a more satisfactory basis than hitherto.

Invitations had been issued to a number of consulting engineers, at the instance of a Provisional Committee, and the invitation was signed on behalf of this Committee by the following members:

Representing Civil Engineering: Messrs. W. T. Douglass, E. L. Mansergh, Midgley Taylor, and Henry Rofe.

Representing Electrical and Mechanical Engineering: Messrs. B. M. Jenkin, W. M. Mordey, Llewellyn Preece, and James Swinburne.

Representing Gas Engineers: Messrs. C. G. Hunt and E. H. Stevenson.

Mr. Midgley Taylor, who presided at the opening of the meeting pending the arrival of Sir William Preece, who was detained, said that the object of calling the meeting was to form an Association of Consulting Engineers. The subject had been before several consulting engineers for the past two years or more, and as some initial step had to be taken, the members who originally took the subject up formed themselves into a Provisional Committee and had held a large number of meetings, with the result that the present meeting had been called to confirm, or otherwise, the action taken by the Committee in the past. The object of the meeting was to see whether the general idea of the formation of the Association met with the approval of consulting engineers in this country.

He felt that the public wanted protecting. At the present time, if municipal authorities erected works, even of large magnitude, they were not compelled to employ a qualified man to advise them, and there was nothing to prevent an absolutely unqualified man going to the particular authority, touting for the work and being employed. Under those circumstances he felt they should endeavour to form an Association such as would not only protect themselves, but would also protect the various public bodies and persons in this country who were anxious to get a properly qualified man to advise them on engineering works. He felt that those unqualified men who endeavoured to take the work out of one's hands, even after the appointment had been made, should not have the standing that would belong to the members of a body such as it was proposed to form. The Committee hoped that the meeting would result in the formation of the Association, but at the same time they wanted to have an open expression of opinion from everyone, whether they were favourable or otherwise. He then called upon Mr. James Swinburne (who had interested himself in the movement from the very beginning) to propose the formation of the Association.

Mr. James Swinburne formally proposed that the Association be formed at once. It was necessary that consulting engineers should work in sympathy with the Institution of Civil Engineers and other institutions, and that they should, in addition, form an Association themselves, not for the purpose of technical papers but purely to guard the interests of consulting engineers as such, and of the public in so far as the latter were bound up with the interests of the consulting engineer. He urged the older members of the consulting profession not to stand aloof because they were in a position sufficiently independent not to be affected by the malpractices of those who were not genuine consulting engineers. By lending their names to the movement they would be helping the younger consultant, who was the man to be looked after.

The motion having been seconded by Mr. E. L. Mansergh, a general discussion took place.

Sir William Preece, who had arrived during the discussion and had taken the chair, said he was entirely in sympathy with the movement. He assured them of the sympathy of the Institution of Civil Engineers, and he was sure that the Committee of the Association would be received heartily by the Council in the discussion of any points that might arise. What they wanted was to band themselves together as brothers in a similar profession with a very strong committee and strong chairman. He then put the resolution, that the Association be formed, to the meeting, and declared it to be carried unanimously.

The Chairman then read the list of names of the suggested Committee, the names being as follows:

As representing *Civil Engineering:* Baldwin Latham, S. R. Lowcock, E. L. Mansergh, Henry Rofe, and Midgley Taylor.

Electrical and Mechanical Engineering: Messrs. Robert Hammond, B. M. Jenkin, W. M. Mordey, W. H. Patchell, Sir Wm. Preece, J. F. C. Snell, James Swinburne.

Gas Engineering: Messrs. C. Hunt, E. H. Stevenson, and Henry Woodall.

No further names being forthcoming, the Committee were elected as above, with power to add to their number, to take what steps they considered desirable for the formation of the Association, and to formulate rules to be submitted to a general meeting to be called in the autumn.

Painting Concrete Structures.—The oil-destroying properties of the alkali in cement have caused trouble in painting concrete, which can be overcome by a method described by Mr. Charles Macnichol in a paper presented to the American Society for Testing Materials recently. He used it successfully for some years, and recommended it as simple and reasonable in cost.

The method consists of treating the cement surfaces with a solution of equal parts by weight of zinc sulphate and water, applied with an ordinary bristle brush, after the cement is dry. If the precaution is observed of allowing 48 to 72 hours as a drying period this treatment will render a cement wall as safe to paint on as an ordinary plaster wall, Mr. Macnichol stated. At his request Dr. A. S. Cushman prepared the following explanation of the chemical reasons for the success of zinc sulphate in such work:

"In regard to the scheme for painting concrete work with a solution of zinc sulphate, in order to make the surface hold a paint coating, it is my belief that the zinc sulphate is very well adapted for this purpose, owing to the fact that when zinc sulphate is brought into contact with the calcium hydroxide (hydrated lime) a chemical reaction results in the formation of calcium sulphate (gypsum) and zinc hydroxide (hydrated oxide of zinc). It is apparent from this that after the surface has become thoroughly dry again it will contain within its pores a mixture of gypsum and zinc oxide. These materials have no bad influence on linseed oil, and, in fact, are frequently used as paint pigments. The reason why such treatment should be necessary before applying a paint coating to the surface of concrete must be apparent to everyone. When Portland cement sets a certain amount of lime is set free in a hydrated condition as calcium hydroxide. This is a strong alkali, and tends to saponify the oil in the paint coating and thus destroy it. The work done by the application of zinc sulphate is to destroy this alkalinity, and change the calcium hydroxide into a mixture of calcium sulphate and zinc oxide. I do not know of anything that would answer this purpose better than zinc sulphate."

Another action taking place, and an important one to the painter, is the filling of the pores of the concrete, which prevents suction, thus keeping the oil paints applied from penetrating too deeply into the cement.—*Engineering Record.*

Surface Rendering for Concrete. — An American contractor, writing to the *Engineering News*, gives the following hints on the best method of plastering concrete walls and ceilings:

"Dirt is the cause of much of the trouble experienced in making joints in concrete and making plaster coats stick. Any weak acid applied with a brush will clean the surface. A weak solution of hydrochloric acid is good. Wire brush work is expensive, and makes dust, and the richer the face the more dust. Wash the surface, not scrub it, with weak acid, and then with water. At the time the mortar is applied the wall should be damp, but not wet. Concrete to be plastered is wetted for the reason that the mortar coat may retain the moisture required to properly set it.

"Having tried rich and lean mixtures, my practice is to use for a first coat a 1 : 3 fairly-dry mixture. It is put on as dry as the mason will consent to handle it, and applied with considerable pressure. The first coat is thin and scratched. Ten per cent. of hydrated lime makes the mortar easy to work, increases adhesion slightly, weakens the mortar, and more than doubles the time of setting. The addition of plaster of Paris weakens the mortar and lessens the time of setting to a degree that embarrasses the plasterer. Too rapid setting lessens adhesion.

"The first coat should obtain its initial set and should be brushed with water before the second coat is applied. Like the concrete surface, it should be damp, but not wet. No matter how many coats are applied, considerable pressure must be exerted, and there must be as little working as possible. Every extra pass of trowel or float tends to consolidate the surface, draw the cement there, and weaken adhesion to the next lower face. Painting with a thin cement grout on the surface of the concrete and even between mortar coats is of no benefit. The best way to obtain the abominable shiny surface so many admire is to put on two cement grout paint coats and polish the last with a steel float. Such surfaces always craze."

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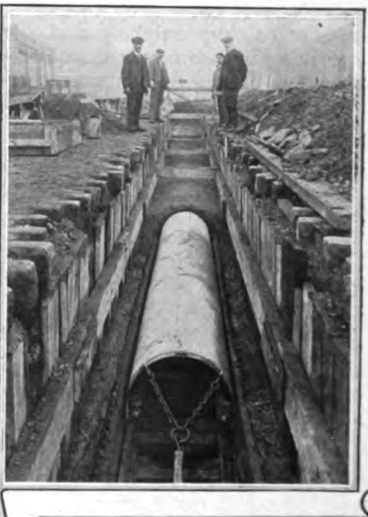
ILLUSTRATIONS SHOW 30in. HALF-ROUND CENTERS IN USE FOR CONSTRUCTING REINFORCED CONCRETE CONDUIT AT WOOLWICH. NOTE THE METHOD OF ROLLING THE CROWN CENTERS AHEAD ON BALLS TO NEXT SECTION.



THE BRITISH STEEL PILING COMPANY,

DOCK HOUSE, BILLITER ST LONDON. E.C.

A Mill Building of Cement Brick.—A mill building which possesses the unique features of being constructed entirely of cement brick made upon the ground has lately been completed at Plymouth, Mass. The Plymouth Cordage Company, for whom the building was erected, owned a large bank of clean, sharp, silicious sand and a bed of gravel containing a liberal per cent. of stone, and it was therefore decided, after some preliminary tests of the material, to use cement brick. The mill is two storeys and basement in height, and covers an area approximately 114 ft. by 430 ft. The bricks were made in four Standard cement-brick machines, operated by hand, each machine turning out twenty bricks at a time. The mixture generally used was one part cement and three parts sand, although for lightly-loaded walls a few bricks were made in the proportion of one of cement to four of sand. All brick used on the outside of the building had a facing an eighth of an inch thick of one part cement and two parts fine sand with the addition of 2 per cent. waterproofing for the cement. In doing the work enough water was used to make a mortar of such consistency that it would hold its shape under compression without flushing water to the surface so as to cause the mortar to stick to the plates. The amount of water used averaged about 8 per cent., and although this amount would seem likely to produce a porous brick, it was shown by tests that the bricks so made were quite impervious to moisture. The cement brick formed such perfect bond with the mortar that the resulting wall was practically monolithic. A valuable feature in connection with the cement brick is the ability to cut it for special places, it being possible to make a cut half an inch thick for the full length of the brick and width. For the entire construction work about 2,400,000 cement bricks were used, requiring in the making nearly 7,500 barrels of cement. The building is a mild grey colour, and while the possibilities of ornamental work with moulded brick and concrete castings are unlimited, they were not tried in the present instance, except as an experiment, for the general design of the building did not call for such detail. As compared with clay brick the cement brick shows strength under compression of 40 lb. more per sq. in., and a resistance to disintegration by sand and rain which does not exist in the case of the former.—*Building News.*

Reinforced Concrete Trestles.—In a paper entitled "Reinforced Concrete Trestles," which was read some little time ago in America, it is stated that as yet no soil has been encountered in which wooden piles could be driven in which it has not been possible to drive the concrete piles. In some soils it is expedient to employ a jet; in others an ordinary drop hammer, a steam hammer, or a combination of the jet with one or the other forms of hammer. It is necessary to lift the drop hammer somewhat more slowly for the concrete pile than for the wooden pile, in order not to set the driver into vibration. A cushion of some elastic material must be placed between the hammer and the pile, and with this precaution very little damage to the head of the pile results, even after long-continued driving. As a matter of fact, it is surprising how much punishment a well-seasoned pile will stand. When it is necessary to drive the pile below the leads, as is generally the case, the follower is placed on top of the cushion. As the loads on these piles are great it is necessary to drive them to refusal, so that accurate knowledge of the required length is necessary. In case it is found that the piles so driven do not reach the elevation called for on the plans the depth of the cap is increased accordingly. If it is found impossible or impractical to drive the piles to the depth anticipated they can be cut off without difficulty. The cut need not be a smooth one, as the casting of the cap will take care of all irregularities of the head of the pile.

Reinforced Concrete Bridges.—The Wexford Council have applied to the Board of Trade for permission to construct a new bridge in reinforced concrete, with an opening span of 30 ft. clear to replace the existing Ferry-carrig wooden structure over the river Slaney.

The Derbyshire County Council have decided to spend £1,000 in building a reinforced concrete bridge over the Trent at the old ferry at Weston, conditional upon the locality subscribing two-thirds of the cost.

Lectures on Law Relating to Engineering.—The Council of the Junior Institution of Engineers (Incorporated) in conjunction with the Council of the Society of Engineers (Incorporated) have arranged for a course of six fortnightly lectures on "The Law Relating to Engineering," to be delivered by Mr. L. W. J. Costello, M.A., LL.B. (Cantab.), the first to be given on October 10th next.

CONTRACTS.

Messrs. James H. Tozer & Son inform us that the following orders have been placed with them for their lock woven mesh: Floors and galleries to Shaftesbury Hall, Portsmouth; roof to 10 No. Dwellings at H.M. Prison, Portland, for H.M. Home Office; floor to sterilising room, Griffin Brewery, Chiswick; floor at the Alton Court Brewery, Ross, Herefordshire; floor to warehouse for Messrs. H. Lowe and Co., Ltd., dry cleaners, Stratford, E.; floors for Messrs. McCaw, Stevenson and Orr; floors to buildings for the Hon. A. Broderick, Ballincoona; floor and staircase for E. A. Lamb, Esq., Brockweir, near Chepstow; floor and staircases at St. Anne's Clergy House, Soho; roof to house for R. H. King, Esq., Carrickbrack, Dublin, Ireland.

The U.K. Fireproofing Co., Ltd., have in hand at present the following reinforced concrete structures: Co-operative Stores, Liverpool; Carnegie Library, Blackpool; Water Tower, Fordham; Pier Pavilion, Bognor; Raft, Princes' Street Bank; Baths, Wood Green. *Fireproof Floors:* Schools at Earlestown; Berkhampsted, Crediton, Coventry, and Bradford; College at Bristol; Co-operative Stores at Wishaw; factories Elverton Street and Caledonian Road; Bank, Poultry, including water tanks and strong rooms; Savings Bank, Glasgow; Canford Manor; St. James's Palace, etc., etc.

ERRATUM.

We extremely regret that in our account of the new Royal Automobile Club in our July issue we omitted to mention that two of the photographs illustrating this article were lent us by Messrs. Waring & White, of 1a Cockspur Street, S.W., who are the contractors for the building in question.

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Three feet long to Twelve feet long.

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Porous Pipes
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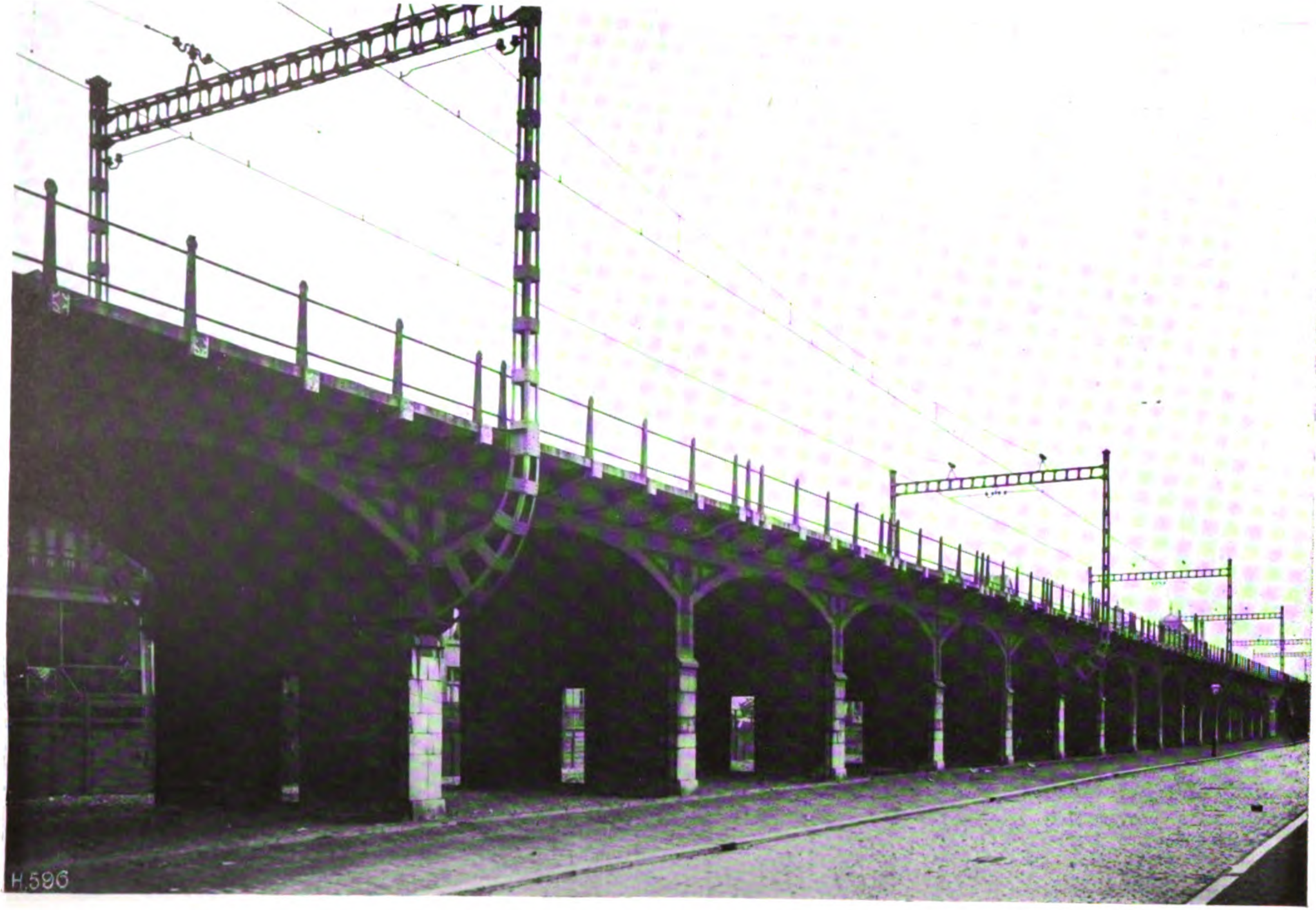


View of a fiinshed portion of the viaduct.
Reinforced Concrete Railway Viaduct, Rotterdam.

(*Frontispiece*
Opp. Contents)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 9. LONDON, SEPTEMBER, 1910.

EDITORIAL NOTES.

FIRE AT THE BRUSSELS EXHIBITION.

THE recent fire at Brussels should serve as a lesson to all exhibition authorities only to use fire-resisting materials in the construction of their buildings.

It is indeed regrettable that the lesson of the Milan Exhibition fire of 1906 was not properly appreciated by those in charge of the Brussels organisation, and that so much valuable property should thus have been lost. Two buildings, it will be remembered, were burnt down at Milan on August 3rd, 1906, yet the form of construction applied there was repeated in the Belgian capital.

For exhibition purposes makeshifts such as the painting of timber with non-inflammable paint do not suffice, nor does the impregnation of textiles and fabrics. Treatment of this kind affords some additional safeguard to the contents of the buildings bu t does not effect the necessary safety of the buildings.

The main structural features of such buildings must be of fire-resisting materials, and among the materials suitable none are better than concrete. Thin concrete slabs in particular lend themselves well to work of this kind, and the cement slate should be most serviceable for roofing. The amount of timber to be found in most exhibition buildings is dangerous in the extreme.

The London County Council is certainly too often the subject of censure owing to its so-called " grandmotherly " regulations, but its rules as to exhibition buildings are wise ones and should be appreciated by exhibition owners and users alike in our metropolis.

THE FIRE RESISTANCE OF CONCRETE.

ONE of the most valuable contributions as to the fire-resistance of concrete in a general way that has recently come to our notice is in a paper by Mr. Frank B. Gilbreth, before the American Society of Mechanical Engineers, entitled " Fires and their Prevention."

The author of that paper is a strong advocate for the use of concrete wherever possible in buildings intended to afford fire protection, and the following paragraph is a quotation from his paper which merits attention. The author does not limit himself to any question of reinforced concrete, but speaks of concrete in a general way, and as there is little doubt but that his findings are absolutely correct, they should be of value not only to those connected with the construction of reinforced concrete, but to all who are interested in every form of application of concrete in buildings:

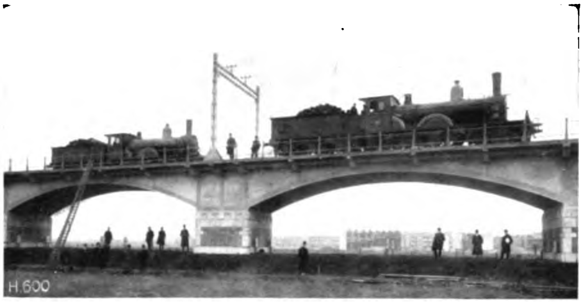
Concrete construction was the best form for the elimination of fires, because the amount of damage done by a fire in a concrete building depended upon circumstances which were within control and were predeterminable. With concrete made of properly-selected fire-resisting materials practically no damage was done, except by prolonged high temperature. The results of recent tests by Professor Ira H. Woolson and his assistant, Mr. J. S. Macgregor, proved conclusively that a properly-designed concrete building, with as few projecting corners as possible, would withstand long periods of the hottest hard-wood fires, with no resulting damage that could not be repaired with mortar. These tests were carried out on full-sized rooms with walls of concrete made of different kinds of material. Concrete for walls could be poured in metal moulds with sufficient accuracy to permit of painting or wall-papering without further plastering or smoothing, which meant that the best of this fire-resisting material was brought to the surface of the wall where the flames would strike. If a fire did occur in a building made of concrete cast in smooth metal forms the damage was less than in any other type of building, and the danger of spreading was less. Water did not injure concrete; in fact, it improved its quality. There was no wood to swell and afterwards to shrink and crack the plastering, and no hollow spaces that the water could flow through, damaging the contents below. A concrete building was watertight from floor to ceiling, and small quantities of water could be easily handled through small scuppers, either into the air space of the vaulted wall or through the wall to the outside. The fire was never hidden by the construction; consequently no unnecessary streams of water were flooded into the building. In a concrete residence there were few parts that could not be made better and cheaper of Portland cement than of wood. The chair rails and picture moulding could be made of concrete, and the ornamentation around the windows and doors could be moulded in metal moulds as cheaply as straight members. Windows might have cement sashes, with wired glass, and self-closing shutters, or self-dropping shutters of rolled up metal or asbestos. The flooring need not be of wood. The spread of a fire into adjoining parts of the same storey was possible in a concrete building only through doorways, pipe holes, etc., and a concrete wall was an ideal barrier to the spread of any fire."

INSTRUCTION IN REINFORCED CONCRETE PRACTICE AND DESIGN.

THE student of reinforced concrete has too long been neglected by our teaching centres. The subject is a very special one, and cannot be adequately dealt with as an appendage to instruction in applied mechanics, theory of structures or building construction generally.

We have often been asked to name a school at which instruction could be obtained either on the practical side or on the theoretical side—the former needed by the craftsman, foreman and clerk of works, as well as by the draughtsman; while the latter is especially needed by the engineer, architect and draughtsman. Hitherto we have been compelled to state that we know of no such course, but we are now glad to be able to announce that the want will not now be unfilled, for a very complete course of lectures has been arranged for the session commencing in September at the London County Council School of Building at Brixton. The authorities conducting the school are to be congratulated on their enterprise.

This country has too long lagged behind America and the Continent in regard to proper theoretical treatment and experimental study of the subject, and it is to be hoped that the example set at Brixton will lead to a general improvement in the matter.



Reinforced Concrete Railway Viaduct, Rotterdam.

A LONG REINFORCED CONCRETE RAILWAY VIADUCT IN ROTTERDAM

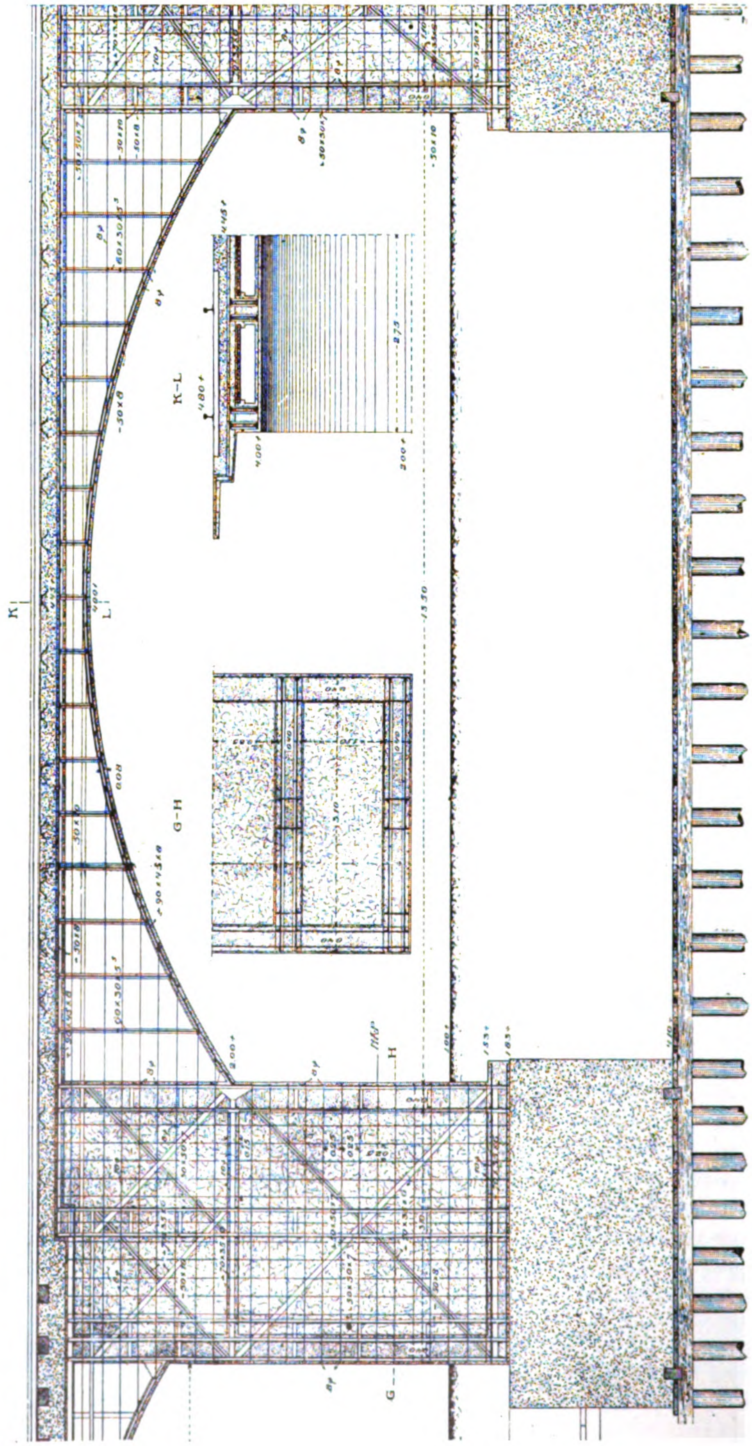
We have on very many occasions dealt with the advantages of reinforced concrete for railway work, and in the present instance we are pleased to be able to give details of one of the largest reinforced concrete viaducts in the world, which has recently been completed for a railway company in Rotterdam.—ED.

One of the largest reinforced concrete viaducts in the world has recently been completed at Rotterdam. It is over a mile in length and carries a two-track heavy electric railway line. In 1900 the Dutch Government authorised an electric railway company to construct a line from a point in Rotterdam to Scheveningen, with a branch to the Hague. The authorities of Rotterdam stipulated that the road, within the city limits, should be placed on an elevated viaduct, so constructed that it would not interfere with street traffic, and that a viaduct should also cross an intersecting steam railway. As the railway crossing is only 3,150 ft. from the end of the city section, it was decided to continue the viaduct to the crossing. The length of the city section is about 2,300 ft., and the total length of the viaduct is about 5,450 ft.

The construction of a masonry viaduct would have entailed great expense, especially in the laying of the numerous and massive foundations, and an iron viaduct was also considered too costly. Hence, in view of the very satisfactory results which had been obtained elsewhere with reinforced concrete, it was decided to use this material.

The construction of the foundations was commenced in 1904, before the character of the superstructure had been determined. The system employed for the city section (2,300 ft. long) comprises ordinary connected foundations for the piers with continuous piling between them. The length of the piles is from 52 ft. to 66 ft. beneath street crossings, and from 46 ft. to 52 ft. beneath the normal spans of about 26 ft. These piles support 8-in. by 12-in. beams, 6-in. by 8-in. cross beams, and 3-in. flooring. Under the normal span the upper surface of the floor is 9·3 ft. below mean water level, but at the street crossing it is placed 13·4 ft. below that level, in order to avoid disturbing water and other pipes. The piers rest on this plank floor, which is covered with a bed of non-plain concrete, the upper surface of which is 6 ft. below mean water level, or 2·7 ft. below the street level. In the section outside the city the reinforced concrete superstructure rests directly on piles.

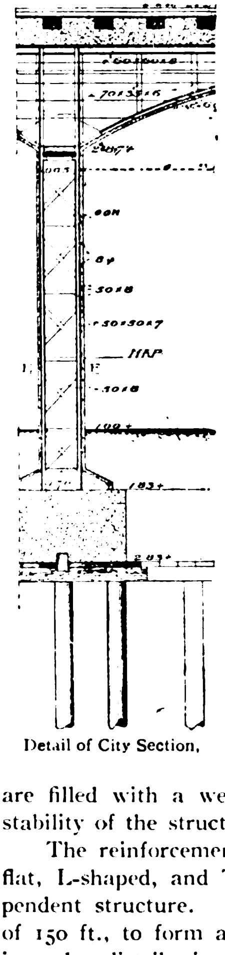
The superstructure of the city section, exclusive of the terminus and yard, comprises sixty-three normal spans, with fifty-eight piers and six street crossings, with one small and twelve large piers. The single span crossings vary in length from 33 ft. to 71 ft. The longest crossing, 88·6 ft., has a middle pier. The piers which



Detail of Main City Section.
REINFORCED CONCRETE RAILWAY VIADUCT, ROTTERDAM.

support the normal spans are 25·6 in. thick, and the distance between these piers is from 26 ft. to 28 ft.; the thickness of the bridge piers varies from 8·2 ft. to 17·5 ft., according to the length of the crossing.

Each of the piers of the normal spans is composed of four rectangular columns of reinforced concrete, 18 ft. high, 15·7 in. wide, and 25·6 in. thick, connected together by two walls, 3 in. thick, and by a common base of reinforced concrete, which distributes the weight over a large surface of the plain concrete foundation. These columns support an arched girder 12 in. wide, 57 in. deep at the ends, and 18 in. deep in the middle. Each girder lies vertically under a rail of the double track. The concave lower surfaces of the four girders of the span are connected together by a sheet of reinforced concrete, 3 in. thick, which is jointed to the walls which flank the columns. The flat upper surfaces of the girders are connected by a concrete floor, of an average thickness of 5 in., which supports the ballast and track.


Detail of City Section.

The floor is constructed by first laying concrete tiles 1·6 in. thick, which are just strong enough to support the rest of the concrete until it sets. The arch below stiffens the structure, and the air enclosed between it, the floor and the wall diminishes the effect of variations of temperature and also lessens the noise produced by the passages of trains. Thus the spaces beneath the spans are made available for use as warehouses, of which several have already been constructed.

On each side the floor overhangs the exterior girders by 30 in. and carries a raised footway 35 in. wide. The trough, 22 ft. wide and 14 in. deep, which is bounded by the footways, is filled with crushed stone, in which the wooden cross-ties are embedded. The ties are 6 in. deep, and consequently rest upon an 8-in. stratum of ballast.

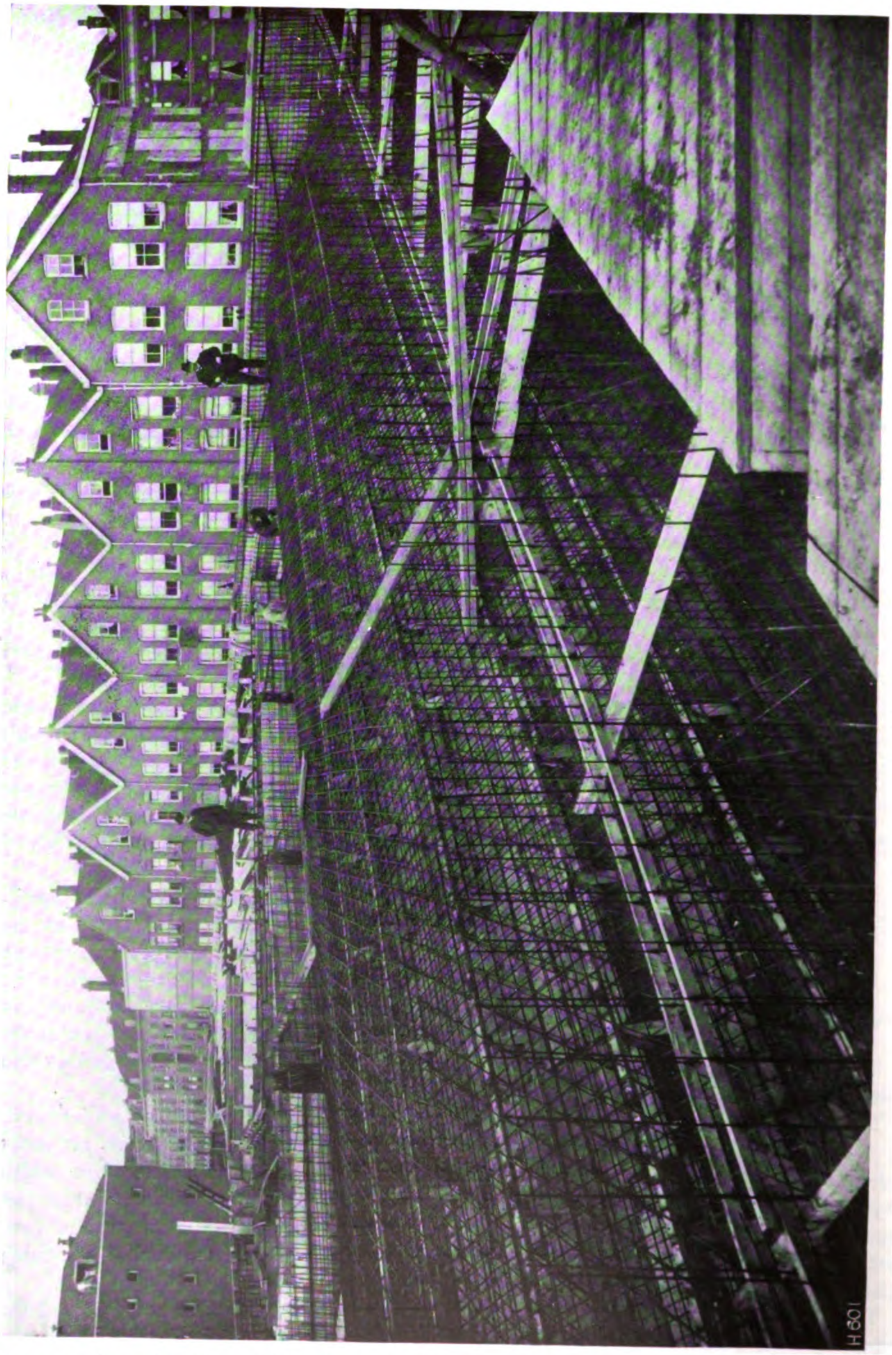
The street crossings are constructed on the same plan as the normal spans, but more massively. The arched girders, though they have the same width and the same depth at the middle as the shorter girders of the normal spans, are 96 in. deep at the ends. This increase in the depth of the girders necessitates the employment of iron cross-ties, in order to maintain the depth of ballast beneath the ties at 8 in.

Each pier of a street crossing is composed of four longitudinal 16-in. walls, connected by two transverse walls of the same thickness and by a base 14 in. thick, which equalises the pressure on the plain concrete foundation. In order to equalise the pressure on the four walls they are connected at the top by the floor of reinforced concrete. The voids between the walls are filled with a weak, non-reinforced concrete, which by its weight increases the stability of the structure.

The reinforcement of most of this city section of the viaduct consists of round, flat, L-shaped, and T-shaped bars, so combined that the profile bars form an independent structure. The inner end of the section is gradually expanded to a width of 150 ft., to form a terminus and shunting yard. In this part of the viaduct the irregular distribution of the tracks made it necessary to change the method of construction. Here the roadbed rests upon an assemblage of arches, each 8 in. thick in the middle and 12 in. thick at the edges.

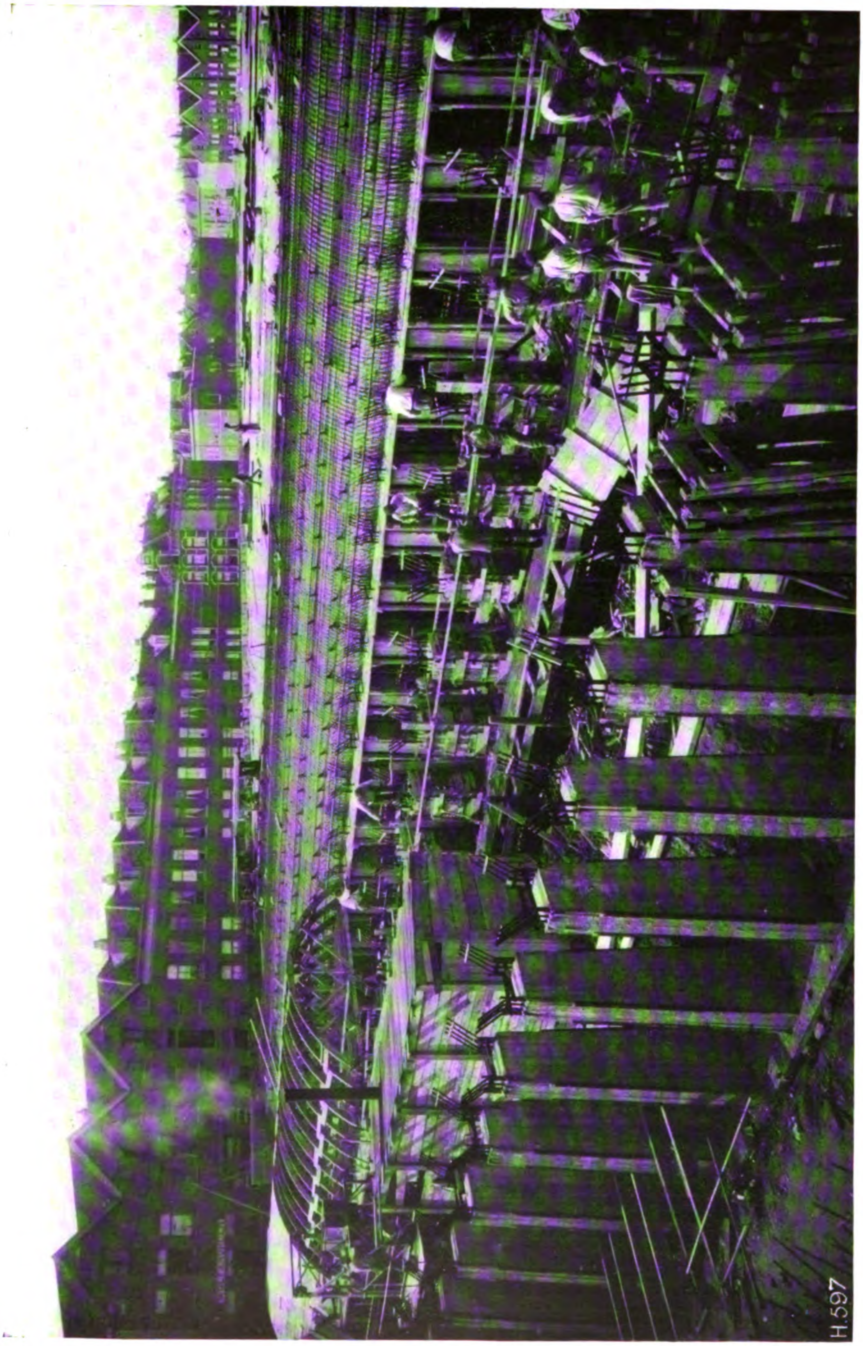
The arches rest on reinforced concrete beams, 24 in. by 32 in., in section, and the beams are supported by columns about 8 ft. high, measuring 16 in. by 32 in. at the top and 16 in. by 45 in. at the base. The edges of the columns are reinforced with

L-bars, 2 in. wide and $\frac{1}{8}$ in. thick. The columns are connected by a base of reinforced concrete 60 in. wide and 12 in. deep. The number of columns under each beam varies with the width of the viaduct, but the maximum distance between consecutive columns nowhere exceeds 6 ft.

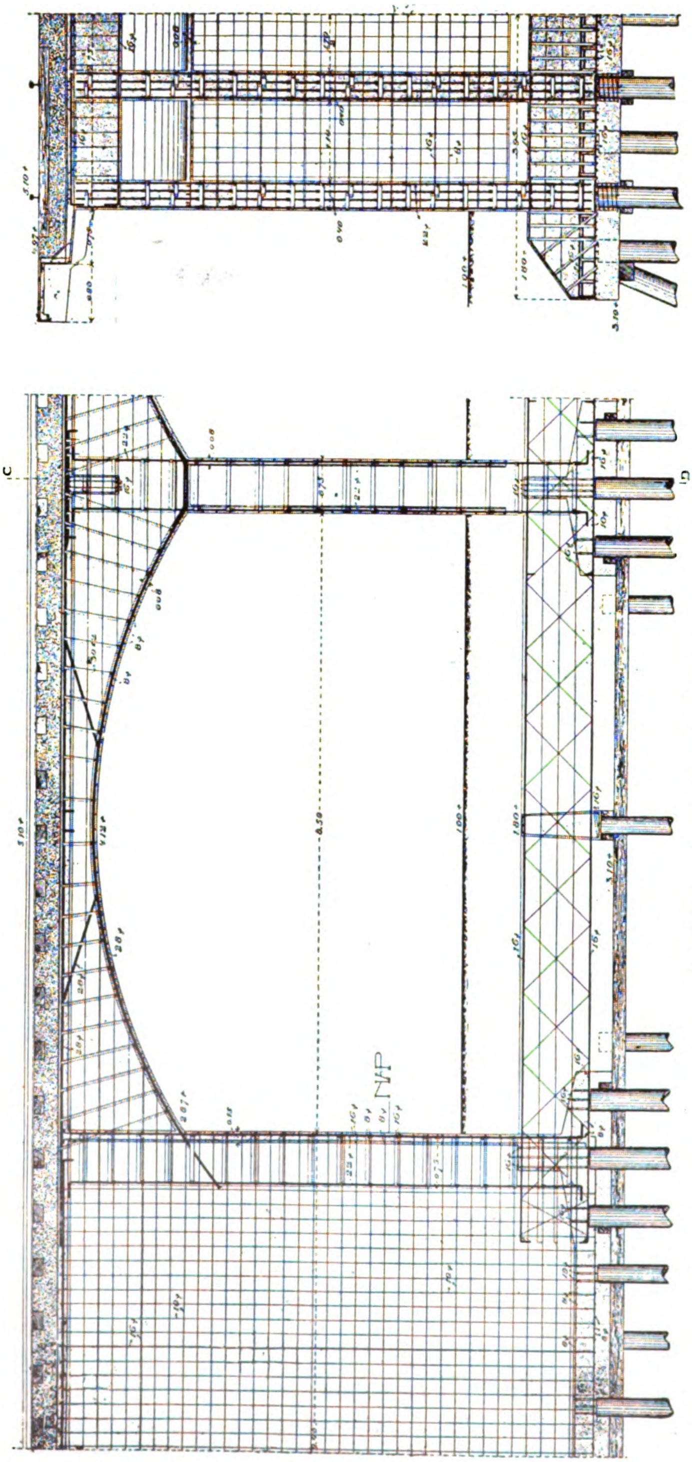


Reinforcement of solid arch construction at terminus.
Reinforced Concrete Railway Viaduct, Rotterdam.

This construction is interrupted by a projected street, which is crossed by the method already described. The crossing is followed by fifteen normal arches, terminating in a large pier. Beyond this point the viaduct is not designed to carry trains, and it is constructed of floors, beams, and columns of reinforced concrete, arranged to accommodate the necessary stairways and auxiliary buildings.



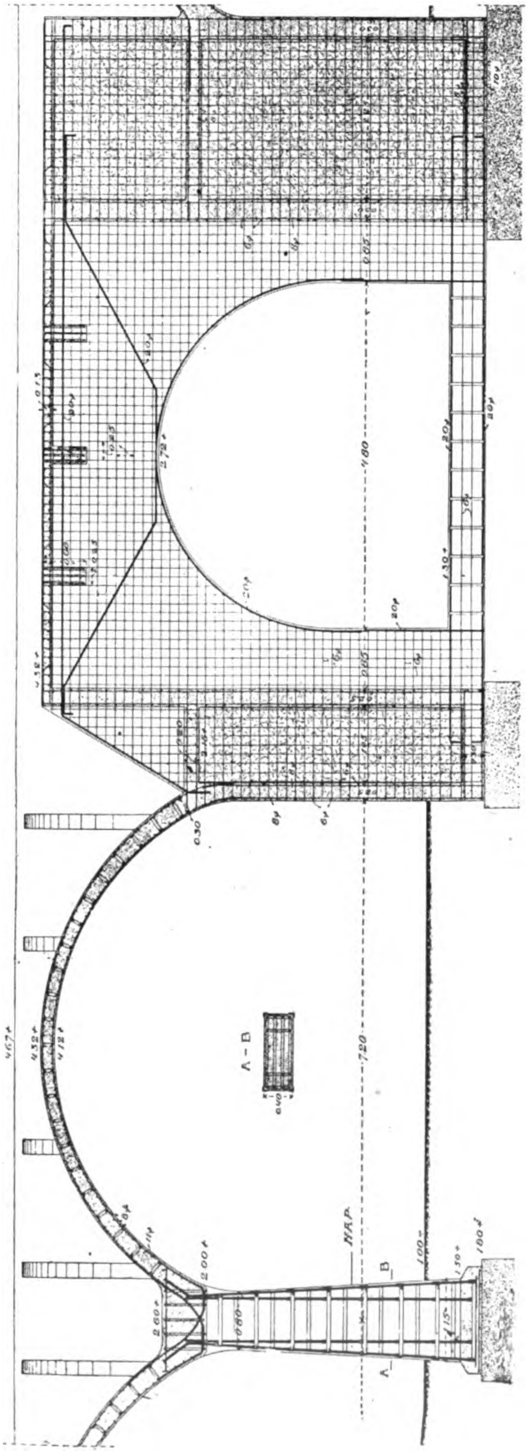
The terminus and yard section in course of construction.
REINFORCED CONCRETE RAILWAY VIADUCT, ROTTERDAM.



Detail of normal span of portion of viaduct outside the city.
REINFORCED CONCRETE RAILWAY VIADUCT, ROTTERDAM.

Four distinct methods are employed in the construction of the section outside the city, which was commenced in 1906. This section is 3,150 ft. long, and includes six street crossings and three aqueduct crossings, in addition to seventy-nine normal spans. Only flat and round iron are used for reinforcing, and, except at the street crossings, the reinforced concrete structure rests directly on piles.

The normal spans resemble those of the city section, but the four columns of each pier rise from a reinforced concrete girder having a cross-section in the form of an inverted T, with a base 8 ft. wide, 28 in. thick at the middle, and 20 in. thick at the edges. This girder rests on twenty-two piles, the heads being surrounded by spirals of round iron and embedded in the concrete. The foundation girders at the two ends of the span are connected by four longitudinal girders 14 in. wide and 51 in. deep, and



Detail of piers.
Reinforced Concrete Railway Viaduct, Rotterdam.

these are connected by an intermediate transverse girder of the same dimensions, forming a strong and rigid foundation.

The street crossings differ little from those of the city section.

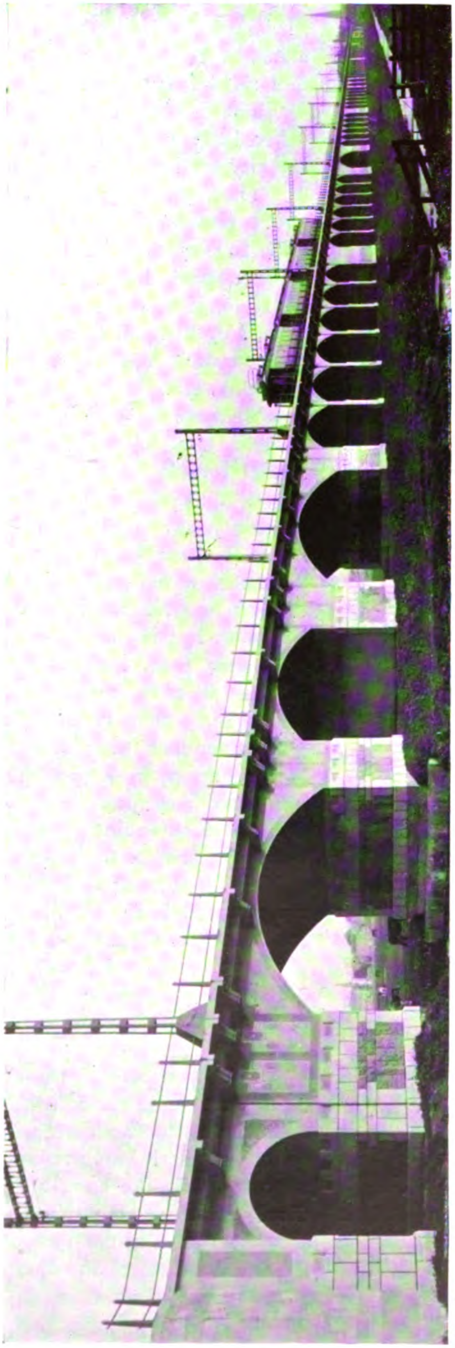
The massive piers of street crossings serve not only to support the long bridge spans but also to resist longitudinal stresses caused by unequal contraction, starting and stopping of trains, etc.

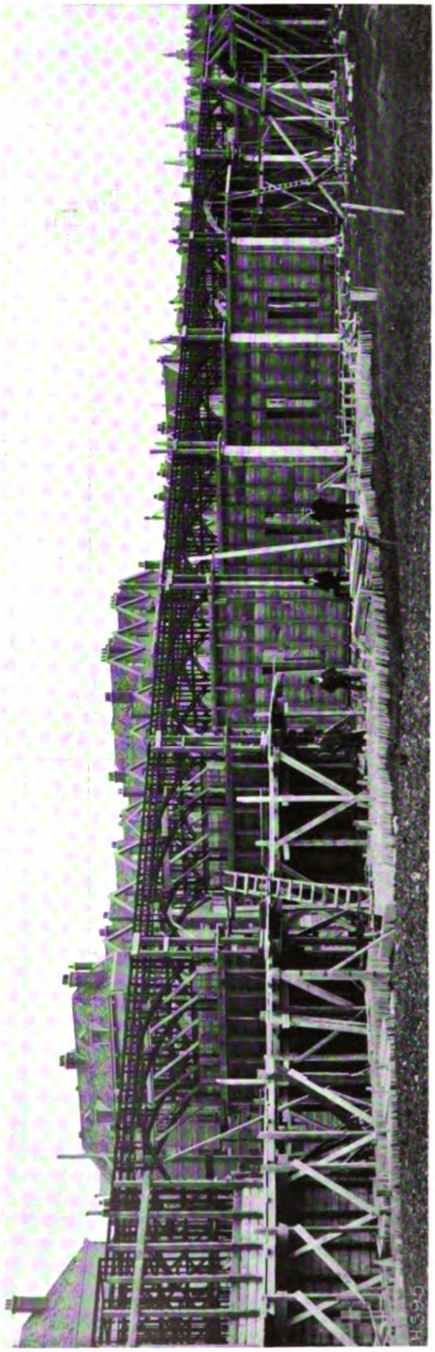
Hence in the section outside the city where street crossings are far apart, it has been deemed necessary to replace in some of the normal spans the longitudinal girders at the top and bottom of the columns by 12-in. walls, extending from the heads of the piles to the floor supporting the roadbed, and to connect these walls at the bottom by a bed of reinforced concrete, 20 in. deep, and extending 8 in. below the tops of the piles.

The longitudinal walls are connected also by 6-in. front and rear walls.

One of the water conduits is crossed by the method adopted for street crossing.

The two other conduits were small enough to be included within normal spans, but as it was necessary to omit the longitudinal girders connecting the bases of the columns, the discontinuity in the foundations thus caused was compensated by the construction of four thick longitudinal walls resting on bases similar to those used beneath the columns.

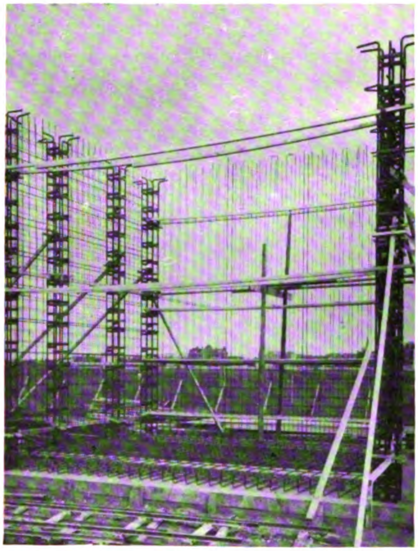


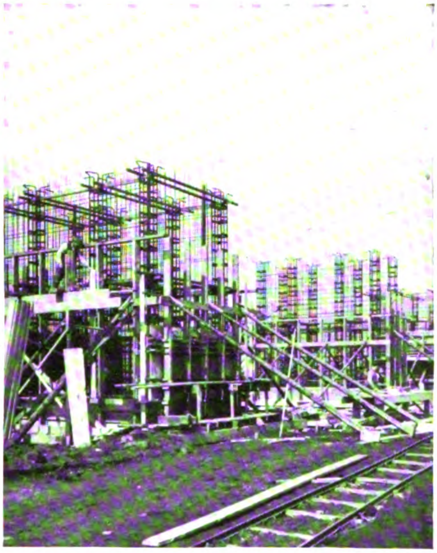


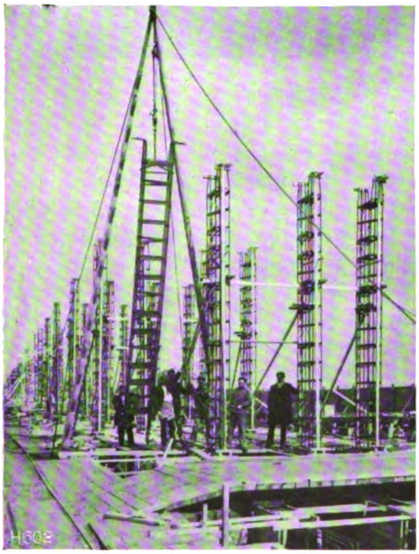
Normal spans in course of construction.
Reinforced Concrete Railway Viaduct, Rotterdam.

These walls are connected by 6-in. front and rear walls and by a 4-in. floor, which covers the water conduit.

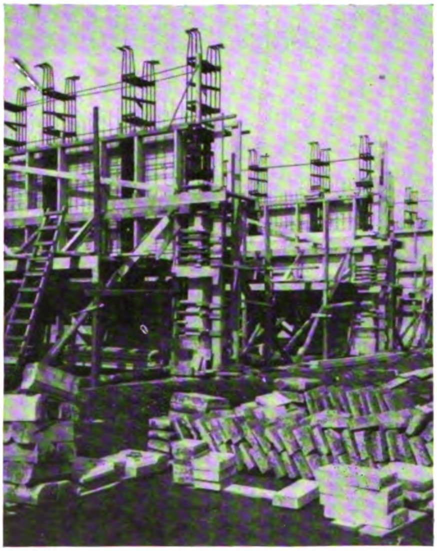
The city portion of the lines passes directly through both residence and business sections, crossing city blocks but not following street lines. In consequence of the extremely light piers, only a small ground space is occupied, and the property beneath the arches is utilised for warehouses and other low buildings.


Reinforcement for a pier.


Reinforcement of piers.



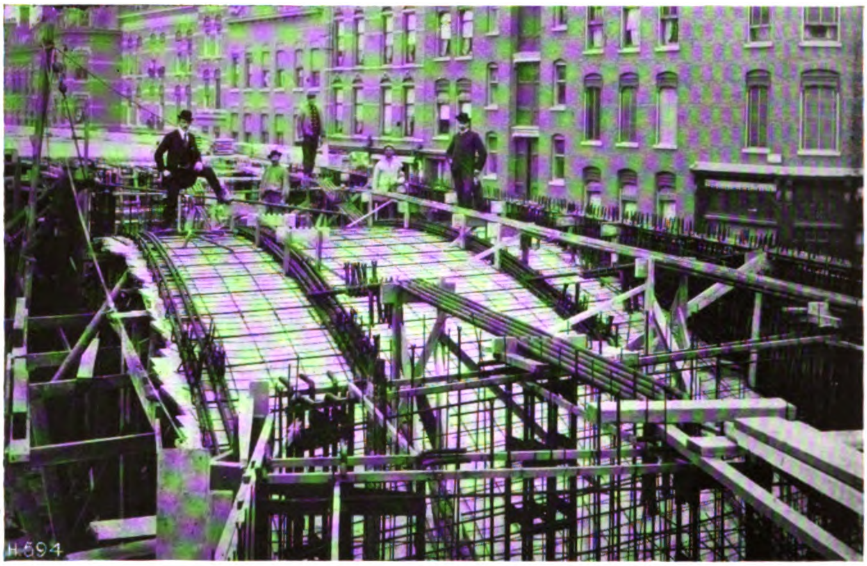
Reinforcement in course of erection.


Centering for piers.

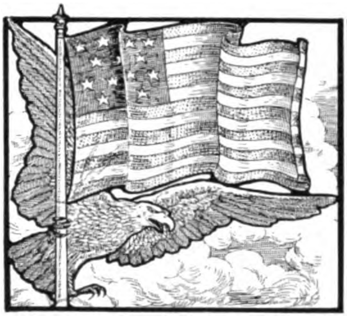
Reinforced Concrete Railway Viaduct Rotterdam.

The whole work has been carried out under the supervision of Mr. A. J. A. Braak, one of the engineers of the Hollandsche Maatschappij tot het Maken van Werken in Beton, contractors for the enterprise.

This article was prepared for us by Mr. J. B. van Brussell, of Brussels, who also supplied us with the photographs from which our illustrations were made.



Reinforcement of one of the street crossings.
REINFORCED CONCRETE RAILWAY VIADUCT, ROTTERDAM.



REINFORCED CONCRETE PIER CONSTRUCTION.

By EUGENE KLAPP, M.Am.Soc.C.E.

We have on many occasions described different methods of reinforced concrete pier construction, and in the present instance are publishing a paper contained in the Transactions of the American Society of Civil Engineers, in which Mr. Eugene Klapp, M.Am.Soc.C.E., describes a novel form of reinforced concrete pier construction.—ED.

A PRIVATE yacht pier, built near Glen Cove, Long Island, has brought out a few points which may be of interest. It is an example of a small engineering structure, which, though of no great moment in itself, illustrates the adoption of means to an end that may be capable of very great extension.

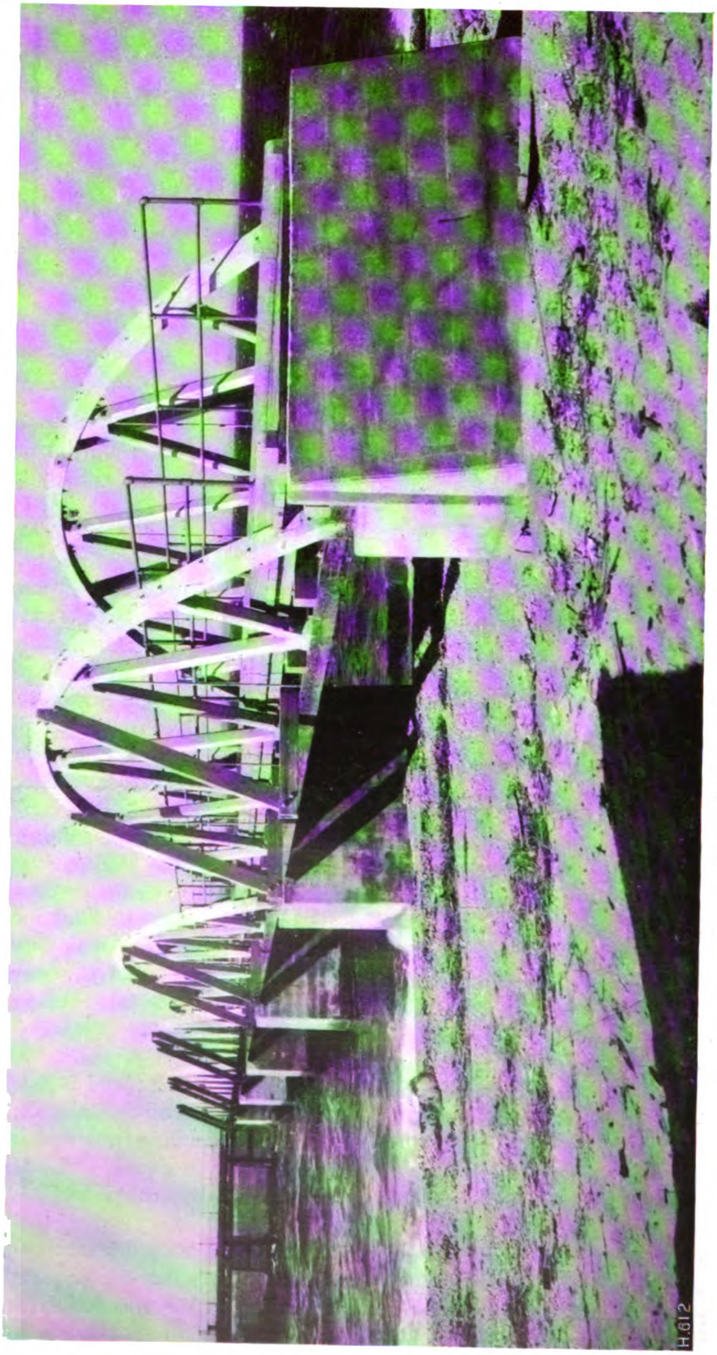
The problem, as submitted to the writer, was to construct a yacht landing at East Island, on the exposed south shore of Long Island Sound, in connection with the construction at that point of an elaborate country residence. The slope of the beach at this point is very gradual, and it was specified that there should be a depth of at least 4 ft. of water at low tide. Soundings indicated that this necessitated a pier 300 ft. long. It was further specified that the pier should be to some extent in keeping with the scale of the place being created there, and that a wooden pile structure would not be acceptable. Besides these æsthetic conditions, wooden piles were rejected because the teredo, in this part of the Sound, is very active. At the same time, the owner did not care to incur the expense of a masonry pier of the size involved. Also, it was desired to unload on the pier all material for the house and grounds during construction, and coal and other supplies thereafter, thus necessitating a pier wide enough to allow access for a car and horse and to provide room for turning at the pier head.

Comparative designs and estimates were prepared for (*a*) a pier of ordinary construction, but with creosoted piles; (*b*) a concrete pier on concrete piles; and (*c*) for a series of concrete piers with wooden bridge connections. The latter plan was very much the best in appearance, and the calculated cost was less than that of the pier of concrete piles, and only slightly more than that of creosoted piles, the latter being only of a temporary nature in any case, as it has been found that the protection afforded by creosote against the teredo is not permanent.

At this point on the Sound the mean range of the tide is about 8 ft., and it was determined that at least 5 ft. above mean high water would be required to make the underside of the dock safe from wave action. There is a north-east exposure, with a long reach across the Sound, and the seas at times become quite heavy. These considerations, together with 4 ft. of water at low tide and from 2 to 3 ft. of toe-hold in the beach, required the outer caissons to be at least 20 ft. high.

To construct such piers in the ordinary manner behind coffer-dams, and in such an exposed location, was to involve expenditure far beyond that which the owner cared to incur. The writer's attention had shortly before been called to the successful use of reinforced concrete caissons on the Great Lakes for breakwater construction by

Major W. V. Judson, M.Am.Soc.C.E., and under patents held by that officer. It seemed that here was a solution of the problem. These caissons are constructed on the shore, preferably immediately adjoining the work.



Yacht Pier, near Glen Cove, New York.

After thorough inspection and seasoning, they are usually launched in a manner somewhat similar to a boat, are towed into position, sunk in place, and then filled with rip-rap.

In this case what was needed was a structure that could be constructed safely and cheaply in the air, could then be allowed to harden thoroughly, and could finally be placed in accurate position.

The weights to be supported were not great, the beach was good gravel and sand, fairly level, and, under favourable circumstances of good weather, the placing of the caissons promised to be a simple matter. Therefore, detailed plans were prepared for this structure.

An effort was made to preserve

some element of the yachting idea in the design, and bow-string trusses, being merely enlarged gang planks, were used to connect the caissons.

The pier was originally laid out as a letter " L," with a main leg of 300 ft. and a short leg of 36 ft. The pier head consisted of eight caissons in close contact, and was intended to form a breakwater, in the angle of which, and protected from the wave action, was to be moored the float and boat landing. After the first bids were received the owner wished to reduce the cost, and every other caisson in the pier head was omitted, so that, as built, the pier contains eight caissons and five 53-ft. trusses. The caissons supporting the trusses are 8 ft. wide and 12 ft. long, and those in the pier head are 12 ft. by 12 ft. On account of the shoal water and the great height of the outer caissons in comparison with their cross-section, it seemed advisable to mould them in two sections. The reinforcement in the side walls consisted of round ½-in. rods horizontally, and ⅜-in. rods vertically, spaced as shown on page 638, together with cross-diaphragms as indicated.

THE CAISSONS.

The caissons were reinforced for exterior pressures, which were to be expected during the launching and towing into position, and also for interior pressures, which were to be expected at low tide, when the water pressure would be nothing, but the filling of the caissons would be effective. The corners were reinforced and enlarged. In order to secure a proper bedding into the sand foundation, a 12-in. lip was allowed to project all around the caisson below the bottom. In the bottom there was cast a 3-in. hole, and this was closed by a plug while the lower section was being towed into place.

The question of the effect of sea water on the concrete was given much thought. The writer is unable to find any authoritative opinions on this subject which are not directly controverted by equally authoritative opinions of a diametrically opposite nature. He thinks it is a question that should be investigated promptly and thoroughly.

There can be no question that there are instances of failures due to the action of sea water and frost on concrete, and that many able and experienced engineers in charge of the engineering departments of the great transportation companies have simply crossed concrete off their list of available materials when it comes to marine construction. It is a subject too large in itself to be discussed as subsidiary to a minor structure like the one herein described, and though many have rejected concrete under these conditions, other engineers equally conservative are using it freely and without fear.

The writer consulted with his partner and others at some length, and considering all the advantages to accrue by the use of these concrete caissons, decided to do so after taking all known precautions.

These precautions consist in :

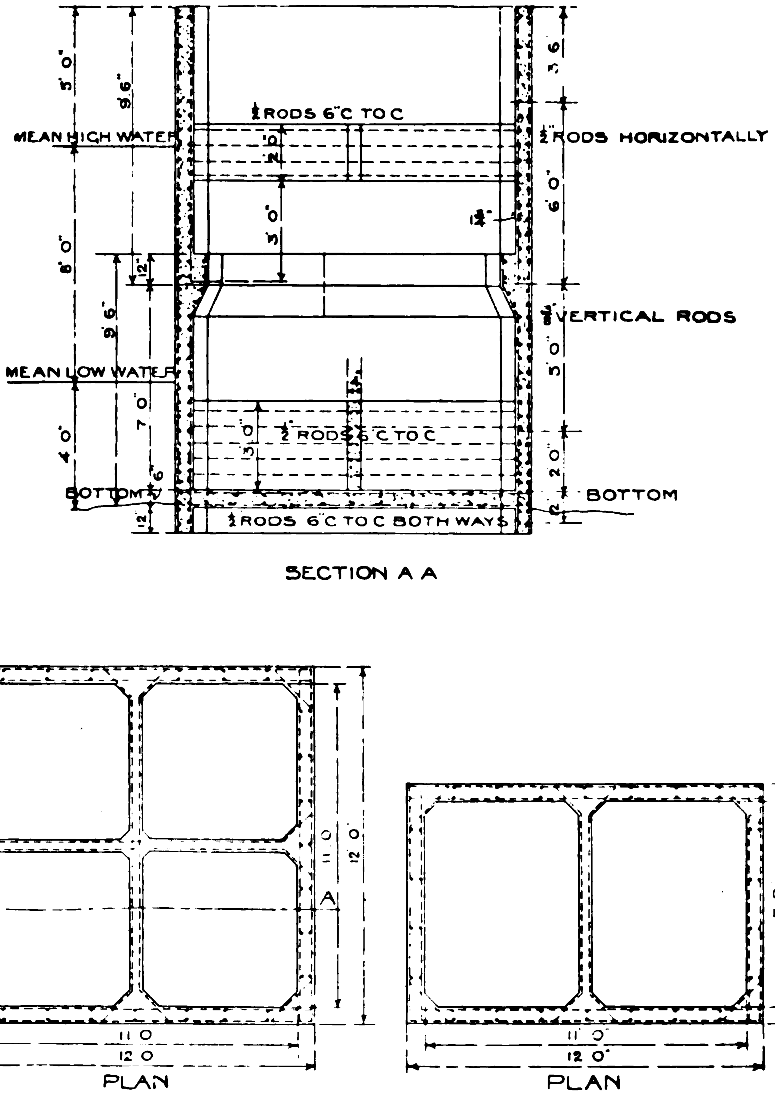
First, the use of cement in which the chemical constituents were limited as follows :

It was specified that the cement should not contain more than 1·75 per cent. of anhydrous sulphuric acid (SO_3) nor more than 3 per cent. of magnesia (MgO); also that no addition greater than 3 per cent. should have been made to the ingredients making up the cement subsequent to calcination.

Secondly, to secure by careful inspection the most completely homogeneous mixture possible, with especial care in the density of the outer skin of the caissons.

Thirdly, a prolonged seasoning process before the new concrete should be immersed in the sea water.

In addition to these well-known precautions, it was decided to try the addition to the cement of a chemical element that should make with the free lime in the cement a more stable and indissoluble chemical combination than is offered by the ordinary form of Portland cement. This was furnished by the patent compound known as "Toxement," which is claimed by the inventor to be a resinate of calcium



Plan and Section.
Pier at Glen Cove, New York.

and silicate of alumina, which generates a resinate of lime and a silicate of alumina in crystalline form. It is further claimed that each of these materials is insoluble in sodium chloride and sodium sulphate, 3 per cent. solution. It was used in all the caissons, excepting Nos. 1 and 2, in the proportions of 2 lb. of Toxement to each 100 lb.

of cement. The first two caissons were not thus treated, and will be held under close observation and comparison with the others, which were treated with this compound.

The mixture used was one of cement, two of sand, and four of gravel. The sand and gravel were from the near by Cow Bay supply, and screened and washed. None of the gravel was larger than ½ in., grading down from that to very coarse sand. The sand was also run-of-bank, and very well graded.

The caissons, after being placed, were filled with sand and gravel from the adjoining beach up to about mean high-water mark, and the edges outside all around were protected from tidal and wave scour by rip-rap of " one man " stone.

The trusses were constructed on a radius of 34 ft., with 8 by 8-in. chords, 6 by 6-in. posts, and 1-in. rods. The loading was figured as a loaded coal cart plus 100 lb. per ft. All lumber was clear yellow pine, except the floor, which was clear white oak. The pipe rail and all bolts below the roadway level, and thus subject to frequent wettings by salt water, were of galvanized iron. The trusses were set 9 ft. 9 in. apart on centres, giving a clear opening of 8 ft. between the wheel guards under the hand-rails. The fender piles were creosoted. The float was 18 ft. long and 12 ft. wide.

A contract was let to the Snare and Triest Company, and work was commenced early in August, 1909. The first caisson was poured early in September, and the last about the beginning of October.

The caissons were all cast standing on parallel skids at about mean high water. It was first intended to construct a small marine railroad and launch the caissons in that manner, rolling them along the skids to the head of the marine railway. This plan was abandoned, however, and by sending in at high tide a powerful derrick scow, many of the caissons were lifted bodily from their position and set down in the water, towed to place and sunk in position, while the others, mostly the upper sections, were lifted to the deck of the scow and placed directly from there in their final position. There was not much difficulty in getting them to settle down to a proper bearing. Provision had been made for jetting, if necessary, but it was not used.

In setting Caisson No. 2 a nest of boulders was encountered, and a diver was employed to clear away and level up the foundation. The spacing was accomplished by a float consisting of two 12-in. by 12-in. timbers, latticed apart, and of just sufficient length to cover the clear distance between the caissons. The first caissons being properly set inshore, the float was sent out, guyed back to the shore, and brought up against the outer edge of the set caisson. The next caisson was then towed out, set against the floating spacer, and sunk in position.

There was some little trouble in plumbing the caissons, but, by excavating with an orange-peel bucket close to the high side and depositing the material against the low side, they were all readily brought to a sufficiently vertical and level position to be unnoticed by sighting along the edge from the shore.

The trusses were all constructed in the contractor's yard at Bridgeport, and were towed across the Sound on a scow. They were set up and braced temporarily by the derrick boat, and then the floor and deck were constructed in place.

On December 26th, 1909, a storm of unusual violence—unequalled in fact for many years—swept over the Sound from the north-east; the waves beat over the pier and broke loose some floor planks which had been only tacked in position, but otherwise did no damage, and did not shift the caissons in the least. The same storm partly destroyed a pier of substantial construction less than a mile from the one in question.

Unfortunately, the work was let so late in the summer, and the restrictions as to seasoning the concrete were enforced so strictly, that the work of setting the caissons could not be commenced until November 11th, thus the entire construction was forced into the very bad weather of the late fall and early winter. As this involved very rough water and much snow and wind, the work was greatly delayed, and was not completed until the middle of January. The cost of the entire dock was about $14,000 (£2,800).

The writer believes that the cost was much less than for masonry piers by any other method of construction, under the existing circumstances of wind, tide, and exposure.

It would seem that for many highway bridges of short span, causeways, and similar structures, the use of similar caissons would prove economical and permanent, and that they might be used very largely to the exclusion of cribwork, which, after a decade or so, becomes a source of constant maintenance charges, besides never presenting an attractive appearance.

Finally, in bridges requiring the most rigid foundations, these caissons might readily be used as substitutes for open wooden caissons, sunk on a prepared foundation of whatever nature, and still be capable of incorporation into the finished structure.

THE CHOICE OF REINFORCEMENT.

By Another Correspondent.

The choice of a suitable reinforcement in reinforced concrete work is a matter of the utmost importance, and the present contribution on the subject calls for attention.

Views on the subject are still very divergent, and those associated with the sale of special forms of bars are apt to take an optimistic view of the value of their particular specialities.

In our August issue (page 552) we published an article of the optimistic character referred to, and whilst intimating that we did not associate ourselves with the views expressed—either for or against—we opened our columns to those who have something to say on the subject.

In the following article will be found the views of a correspondent who has availed himself of this invitation. Further expressions of opinion will be welcome.—ED.

So far as can be judged by its contents, the ably-written article in the August number of CONCRETE AND CONSTRUCTIONAL ENGINEERING is evidently the work of a firm interested in the sale of corrugated bars made of high-carbon steel.

It is quite natural that such a firm should "take an optimistic view of the value of their particular specialities," and equally natural that their opinion should not be shared by experts generally, and in particular by independent engineers who have no wish to see the progress of reinforced concrete retarded by unnecessary patents. During the past twenty years many thousands of important works have been executed in reinforced concrete, composed simply of good concrete combined with plain bars in accordance with theoretical and practical requirements.

In the present article the writer deals first with the suggested use of high-carbon steel; secondly, with the proposed employment of corrugated bars; and thirdly, with the efficiency of natural adhesion between concrete and steel.

HIGH-CARBON STEEL.

Apart from the brittleness characterising high-carbon steel when first supplied its increased brittleness after manipulation, and the excessive cost of bending always involved, this material is far more expensive than mild steel, even when it is obtained in the form of plain round bars. Your correspondent admits all these drawbacks, but attempts to gloss them over by a few vague palliative remarks. The facts remain, however, that high-carbon steel is unsafe because brittle, and costly because of its high first cost and because of the expense attending its manipulation. If the greater tensile strength of high-carbon steel could be utilised in reinforced concrete design the financial objection to this material might be removed, or reduced to some extent. But it happens that the elastic co-efficient of high-carbon steel is no greater than that of mild steel. Therefore, the high-tensile resistance of the metal cannot be developed in practical design without causing excessively wide cracks in the concrete of beams and members subject to flexure. This objection is fully recognised by your correspondent, and, in itself, is a sufficient justification for the universal employment of mild steel.

Another practical objection is that, owing to the relatively low elastic co-efficient of high-carbon steel, as compared to its ultimate tensile stress, the position of the neutral axis would be so high as to make a considerable reduction in the available area of concrete working in compression, frequently making it impossible to utilise the permissible safe tensile stress in the steel. Where such cases occur, the position is that all the extra cost incurred for expensive steel has been absolutely wasted. Moreover, cases very often arise where, owing to structural or architectural requirements, the dimensions of beams must be kept within certain specified measurements which involve the use of more than the theoretical "economic" amount of reinforcement. Now, it is a well-known fact that as the amount of reinforcement is increased so the actual tensile stress that can be developed is decreased. Hence, beams have very frequently to be designed where the working stress cannot possibly be more than from 5,000 to 10,000 lbs. per sq. in., and it would be a perfect waste of money to use steel capable of being stressed up to 20,000 lb. per sq. in.

These are practical objections deserving mention, although they may not be considered suitable for an article written exclusively in the interests of a firm engaged in pushing the sale of high-carbon bars.

CORRUGATED BARS.

Your correspondent is obliged to admit that the cracks caused by high-tension steel "are sufficiently serious to practically prohibit the use of high-carbon steel at correspondingly high stresses," except when special provision is made to reduce these cracks. The writer has carefully read the ingenious but absolutely imaginary proposition of your correspondent on the subject of crack prevention. His exposition reads very well, and may appear convincing to the uninitiated.

It is based upon two gratuitous and perfectly inaccurate assumptions—

(1) That cracks "cannot appear" without some slipping of the metal.

(2) That "indentations or projections" limit the size of the cracks.

The first assumption is obviously untenable, for the tiny hair-cracks that develop along the underside of a beam loaded beyond certain limits are very uniformly distributed and gradually widen as the stress in the steel is increased, thus showing perfect co-operation between the concrete and the steel from beginning to end and refuting the illogical suggestion that these invisible cracks are due to slipping of the steel; as a matter of fact, they are due rather to complete maintenance of the natural adhesion bond.

Professor Turneaure's tests to destruction clearly demonstrate the point that in beams reinforced with plain bars the effect of natural adhesion is to develop the full extensibility of the concrete so that its behaviour is quite different from that of plain concrete.

Various bulletins by Professor Talbot state distinctly that among the numerous beams tested to destruction at the University of Illinois slipping of the steel only took place after failure of diagonal tension had modified the stress distribution.

Your correspondent seems to have evolved an intellectual conception of what takes place in a stressed beam. The picture suits his argument admirably, but does not agree with the well-established fact that steel bonded by natural adhesion prevents the development of isolated cracks in concrete and promotes a form of extensibility so perfect that Considère was quite unable to identify it with a state characterised by exceedingly fine and uniformly distributed surface cracking.

Turning now to corrugated bars, we have only two alternatives for consideration:

(1) That the adhesion bond remains perfect.

(2) That the adhesion bond fails.

Alternative (1) needs not attention beyond the remark that overwhelming practical experience and scientific research during the past twenty years prove the contingency cannot occur in well-designed beams. Hence the costly and troublesome methods attending the use of corrugated bars are useless.

Alternative (2), being a practical impossibility, only lends itself to speculative mental exercise, but we may point out that if the natural adhesion bond were to fail the advocated indentation and projections could not supply its place, and would simply have the effect of causing a series of large and dangerous cracks by the concentration of stress of various points along the beam. Your correspondent, supposing the failure of adhesion, admits that the cracks caused by his bars would measure $\frac{1}{500}$-in. wide over the length of 3 in. But he is wrong in supposing that an abrupt projection of the metal could possible divide out the gap into a series of small cracks. On the contrary, it must create one large crack.

Comparing this state of things with what happens in the case of natural adhesion with mild steel at 16,000 lb. per sq. in. we find that the collective cracks in the length of 3 in., measuring $3 \times \frac{16000}{30000000} = \frac{1}{625}$ in. wide, and that this would be made up of numerous hair cracks by the co-ordinate action of the steel and the concrete. Thus the one mechanical bond crack would be hundreds of times wider than each of the invisible cracks accompanying the development of extensibility by the natural adhesion bond.

The net upshot is that the so-called mechanical bond does not remove but in reality accentuates the dangers attending the use of high carbon steel.

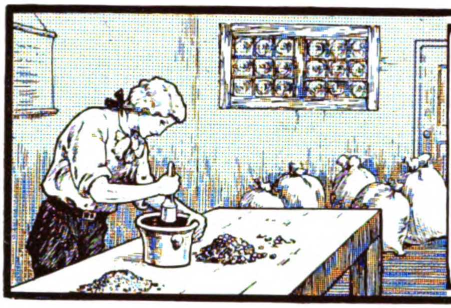
NATURAL ADHESION BOND.

When confronted with the high values found by all the best authorities for the adhesion between concrete and plain steel bars your correspondent perhaps naturally seeks to discount these by quoting an isolated set of tests where a smaller value was ascertained.

It ought in fairness to be pointed out that most laboratory tests of the kind give results much lower than those attained in actual construction because in the former case the bars are always quite straight and smooth, while in the latter they are invariably a little crooked and rough. Thus tests by the *Commission du Ciment Armé* showed that in practical beams with bars only approximately straight the adhesion bond reached the high value of from 1,138 lb. to 1,308 lb. per sq. in., and it should be remembered further that in the case of bars bent up at each end there is in reserve a mechanical bond of far more practical nature than any series of indentations and projections.

Plain round bars with natural adhesion never cause injury to the surrounding concrete, whereas, as proved by the investigations of Professor Bach in Germany and Professor Talbot in America, corrugated bars always tend to split or burst the concrete in which they are embedded. This serious disadvantage of deformed bars is strongly emphasised by Professor Morsch, of Zurich, who shows that it is particularly evidenced "in the small items of T beams, especially at their bottoms, where they will have a splitting effect, and thus cause premature failure of bond."

The two diagrams and accompanying calculations given by your correspondent require little attention, for they are carefully prepared to suit his argument. *Fig.* 1 represents a form of design we hope will never be adopted in practice, and like that in *Fig.* 2 it provided for bars specially chosen to make the bond stress appear excessive, a result in part attained by adopting the working stress of 20,000 lb. instead of 16,000 lb. per sq. in. for the steel. The writer has redesigned both these details, with the result that the maximum bond stresses are reduced to 80 lb. and 84 lb. per sq. in. respectively. and they could be brought even lower if thought desirable.



MIXING AND PLACING CONCRETE BY HAND.

By PERCY H. WILSON, Assoc.M.Am.Soc.C.E., and CLIFFORD W. GAYLORD.

We frequently hear from readers that some of the most elementary facts regarding concrete are not known in the ranks of the building trade, nor among estate managers, farmers, gardeners, etc.

There is no book or treatise on the subject easily available to what we may term the lay or semi-lay reader, other than the booklets of the Associated Portland Cement Manufacturers (1900) Ltd., entitled "Every-day Uses of Portland Cement."

We thus think a simple recapitulation of the elementary features of concrete in this journal may be of use to readers who wish to pass on the information to those of lesser technical education, and we present, with this object in view, extracts from a very excellent "bulletin" recently issued by the Association of American Portland Cement Manufacturers.—ED.

WITH the rapid decrease of our timber supply, and the resulting increase in price of lumber, there has come a necessary demand for a new building material. Nowhere has this demand been felt more keenly than on the American farm, where lumber has been practically the only building material. However, on account of the farmer's nearness to the timber itself, he has been the last to feel the full effect of the shortage. Owing to the many idle hours on the farm, due to rainy days and the winter months, the farmer figures his labour at a very low price, when not spent in actual farm work. Therefore, as materials are practically the only costs figured, the doubling of lumber prices doubled the cost of the average farm building. The uses of brick and stone masonry were well known. But with bricks the whole material had to be manufactured at some distant kiln, shipped on the railroad, and hauled from the station, generally at a time when the roads were in the worst condition. Stone in the form of rubble masonry was used for foundations, but was too costly and cumbersome to be used above the ground. Accordingly the progressive, practical American farmer has hailed with delight the advent and rapid rise of the use of the new building material, concrete—a manufactured stone as durable as rock, stronger than brick or rubble stone masonry, adaptable to practically any form of building detail, and lastly, but far from least, cheap and fire-proof.

The adaptability of concrete as a building material is the one great characteristic which makes it possible to take advantage of its other characteristics in practically every form of construction. Concrete is to-day used to advantage in over two hundred and fifty different commercial forms, ranging from great engineering structures, containing thousands of cubic yards of material, to a concrete fence-post, containing only $\frac{1}{20}$ of a cubic yard.

PURPOSE.

This bulletin is issued for the purpose of instructing the individual user, the practical man, who desires to take advantage of the utility of Portland cement concrete and yet has not the time to obtain a technical knowledge of this subject. This bulletin tells him what concrete is, how it can be made, and what he must not do if he is to meet with success. No attempt will be made to discuss reinforced concrete design, as that subject will be handled in subsequent bulletins, on specific uses.

WHAT CONCRETE IS.

Concrete is the manufactured stone formed by mixing cement, sand, and stone, or gravel (pebbles) together. Various proportions of each are used, depending upon the use to which the concrete is put. The mixture in which all the spaces (called voids) between the stone or gravel are filled with sand and all the spaces between the sand are filled with cement is the ideal mixture. This mixture is rarely obtained, as the voids in each load of gravel and sand vary slightly, and in order to be absolutely safe, a little more sand and a little more cement than will just fill the voids are used.

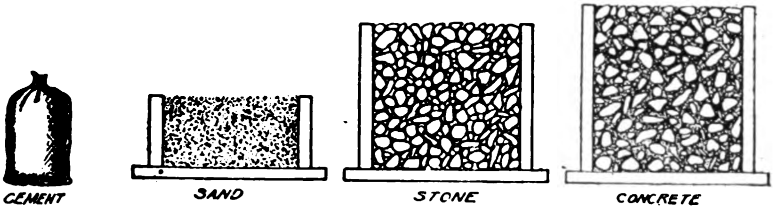
TABLE I.

Showing the Quantities of Materials and the Resulting Amount of Concrete for Two-bag Batch.

Kind of Concrete Mixture.	Proportions by Parts.			Two-Bag Batch.						
				Materials.				Size of Measuring Boxes. Inside Measurements.		Water* in Gallons for Medium Wet Mixture.
	Cement.	Sand.	Stone or Gravel.	Cement.	Sand.	Stone or Gravel.	Concrete.	Sand.	Stone or Gravel.	
				Bags.	Cu. ft	Cu. ft.	Cu. ft.			Gals.
1 : 2 : 4 Concrete ...	1	2	4	2	$3\frac{3}{4}$	$7\frac{1}{2}$	$8\frac{1}{2}$	2′ × 2′ $11\frac{1}{2}$″	2′ × 4′ $11\frac{1}{2}$″	10
1 : 3 : 6 Concrete ...	1	3	6	2	$5\frac{3}{4}$	$11\frac{1}{2}$	12	2′ × 3′ $11\frac{1}{2}$″	3′ × 4′ $11\frac{1}{2}$″	$13\frac{1}{2}$

* See note on water.

Proportions.—Table No. I shows the amount of stone, sand, and cement used in the various grades of concrete work. In explanation of the proportions, they are always measured by volume. A 1 : 2 : 4 mixture means one part cement, twice as much sand, and four times as much stone or gravel, making the whole mixture consist of seven parts. A 1 : 3 : 6 mixture means one part cement, three times as much sand, and six times as much stone or gravel, making the whole mixture consist of ten parts.



Quantities of Cement, Sand and Gravel in 1:2:4 Concrete Mixture, and the Resulting Quantity of Concrete.

Example: Suppose a 1 : 2 : 4 concrete mixture is specified. Then, under the column heading "Kind of Concrete Mixture" (Table I), take the line marked 1 : 2 : 4 Concrete, and running to the right across the page, all the quantities of materials can be found. Under the "Proportions by Parts" it can be seen that there is one part cement, two parts sand, and four parts stone or gravel, and this is the mixture specified. Then, running further across the page are found the quantities of cement, sand, and stone or gravel under their respective headings, to be mixed together in a two-bag batch. There are two bags of Portland cement, $3\frac{3}{4}$ cu. ft. of sand, and $7\frac{1}{2}$ cu. ft. of stone or gravel. In the next column the quantity of concrete resulting from the above mixture is found to be $8\frac{1}{2}$ cu. ft. Under "Size of Measuring Boxes" it is found that the sand should just fill a box 2 ft. long by 2 ft. wide by $11\frac{1}{2}$ in. deep, and the stone or gravel, a box 4 ft. long by 2 ft. wide by $11\frac{1}{2}$ in. deep. The next column gives 10 gallons as the amount of water to be used as a trial in mixing the first batch.

How Quantities are Measured. — One barrel of Portland cement contains 3·8 cu. ft. of packed cement, or one bag of cement ($\frac{1}{4}$ barrel) contains ·95 cu. ft.

Sand and stone (or gravel) are measured loose in the boxes. Do not pack them.

Two-bag Batch.—A two-bag batch of concrete requires two bags of cement, the sand and stone or gravel being proportioned accordingly as shown. For a four-bag batch, multiply the amount of stone and gravel by two, double the cubic contents of the measuring boxes, and use four bags of cement.

Measuring Boxes.—The inside dimensions for the measuring boxes for sand and stone or gravel are given. These boxes are made with straight sides of any kind of rough boards and have no top or bottom.

Water.—The amount of water given is only approximated. Use this amount for the first batch; if too wet for the use desired, reduce the amount used; if too dry, increase the amount. Always use a bucket in measuring amount of water, as this secures uniform results. See heading "Consistency," for proper wetness of concrete.

The Amount of Concrete.—The less the voids in stone or gravel, the greater will be the volume of the concrete. In general, the amount of concrete will be greater than shown in Table No. I, especially when gravel is used.

1 : 2 : 4 Concrete.—A very strong mixture used for all kinds of reinforced concrete, such as floors, beams, girders, columns, etc., subjected to very heavy loading or vibrating machinery; is water-proof and air-tight when used on the farm for silos, tanks, cisterns, fence-posts, troughs, culverts, building walls, etc.

1 : 3 : 6 Concrete.—A strong mixture, but of less strength than 1 : 2 : 4 concrete, sometimes used for reinforced concrete in floors and walls, but more generally used without reinforcement in foundations, footings, ground floors, sidewalks, gutters, etc.

Cautions for Variations in Mixture.—If sand is very fine, increase the cement 10 per cent. to 15 per cent.

If the mixture looks streaky, and does not have a uniform colour, it is not fully mixed.

If the mixture does not work well, the sand and cement not filling the voids in the stone, reduce the percentage of stone slightly, but first be sure the concrete is properly mixed. Half-mixed concrete may present features that are entirely eliminated by turning it over once or twice more.

THE MATERIALS TO USE.

CEMENT.—Portland cement is a manufactured product, the principal value of which is its ability to adhere to the various materials used in masonry construction.

On adding water to the dry cement until the whole becomes a soft, sticky paste, the cement is in a plastic state, and will remain so for about half an hour, depending somewhat upon the temperature of the air. It then begins to harden or "set." To disturb the concrete after this initial set has started means a decided loss in strength. To disturb it after this initial set is well under way means to DESTROY the concrete.

So remember that: Portland cement concrete must be placed in position within twenty or thirty minutes from the time it is first wet.

There are several other minor considerations which should be observed, as follows:

1. The binding value of Portland cement is lowered by exposing the concrete to a hot sun during the first four or five days after it has been placed.

2. A green cement mixture which can be easily frozen at a temperature below 32° F., should not be allowed to freeze. Freezing does not materially affect the binding quality of good Portland cement, provided the concrete does not freeze till after placing and is not subjected to any load until after it has been thawed out and allowed to set in the usual way. It is safest to avoid mixing on days when the temperature is below 32° F. (freezing). In no case should fresh manure be placed over very green concrete to protect it from freezing, as this will spoil the surface of the concrete.

How Portland Cement Comes.—Portland cement comes in cloth sacks or wooden barrels. The best way to handle it for the average user is in cloth sacks. The bags must be kept dry and untorn, and shipped back by freight, in exact accord with the requirements of the cement company. Barrels are too bulky to handle easily and are too large a unit for measuring. The weight of the shipping units of cement varies slightly, but in general a cloth bag contains 95 lb. of cement, and four such bags make a barrel of 380 lb.

How to Keep Portland Cement.—Cement must be stored in a dry place. It absorbs moisture from the atmosphere with great readiness, and soon becomes lumpy, or even a solid mass, when kept in a damp place. Such cement is useless and must be thrown away. Lumpy cement should not be broken up and used again, even if this can be readily done, as it has lost by far the greater part of its adhesive value. In storing cement throw wooden blocks on the floor, place boards over them, and pile the cement on the boards.

SAND.—Sand should be clean, coarse, and free from loam, clay, and all vegetable matter.

Cautions.—Do not use very fine sand. If there is a large quantity of fine sand handy get a coarse sand and mix the two sands together in equal parts; this mixture is as good as coarse sand alone. If the sand is not clean wash it before using. The simplest way is to build a loose board platform from 10 to 15 ft. long, with one end 12 in. higher than the other. On the lower end and on the sides nail a 2 x 6 in. board on edge to hold the sand. Spread the sand over the platform in a layer 3 or 4 in. thick and wash with a ¾-in. garden hose. The washing should be started at the high end and the water allowed to run through the sand and over the 2-in. x 6-in. piece at the bottom. A small quantity of clay or loam does not injure the sand, but any amount over 5 per cent. should be washed out.

Remember, if fine, dirty sand is used, the strength of the concrete will be limited by the strength of the sand and only a part of the full value of the Portland cement will be developed.

STONE OR GRAVEL.—The largest part of the concrete is the crushed stone or gravel (pebbles, as they are often called). Other materials are sometimes used in place of stone or gravel, such as ashes, cinders, coke, brick-bats, etc., but it is safer to use crushed stone or gravel. The stone or gravel should be clean : that is, free from loam, clay, or vegetable matter. Especial care should be taken to inspect the pebbles, as often clay is deposited in a thin layer on their surface and this layer prevents the binding of the cement. Gravel can be washed in the same way as sand, but more easily, as the water flows through the larger voids in the gravel more readily than through the voids in the sand. Dust may be left in the crushed stone, but some care should be taken to see that it is distributed evenly throughout the whole mass, and slightly less sand used.

Size.—The proper size of stone (or gravel) varies with the form of construction. Use anything up to 2½ in. in diameter for foundations or large thick structures. Use 1½ in. and under (generally about ¾ in.), graded, for thin walls and reinforced concrete. Use ½ in. and under for a finish or very hard coating The best results are obtained from a mixture of sizes graded from the largest to the smallest. This reduces the spaces or voids between the stones or pebbles and makes a more compact concrete. It also requires less sand and less cement.

WATER.—Water for concrete should be clean and free from strong acids and alkalies. It can be readily stored in a barrel beside the mixing board and placed on the concrete with a bucket, as this allows careful measurement and insures the desired wetness of the mixture.

NATURAL MIXTURE OF BANK SAND AND GRAVEL.—Naturally mixed bank sand and gravel are sometimes found in the right proportions for making concrete. Generally, however, there is far too much sand for the gravel, and great care should be exercised in using this class of material. Unless the mixture runs very even throughout the bank, and is found to be made up of one part sand to two parts gravel, it is better to screen the sand out of the gravel and prepare the materials in the usual way.

Below is a table showing the quantities for a natural mixture of bank sand and gravel. The quantities can be found in the same way as in Table I.

TABLE II.

SHOWING THE QUANTITIES OF MATERIALS AND THE RESULTING AMOUNT OF CONCRETE FOR TWO-BAG BATCH, USING NATURAL MIXTURE OF BANK SAND AND GRAVEL.

Kind of Concrete Mixture.	Proportions by Parts.		Two-Bag Batch for Natural Mixture of Bank Sand and Gravel.				
	Cement.	Natural Mixture of Sand. and Gravel.	Materials.		Con-crtee.	Size of Measuring Boxes.	Water in Gallons for Medium Wet Mixture.
			Cement.	Natural Mixture of Sand and Gravel.		Mixture of Sand and Gravel.	
			Bags.	Cu. ft.	Cu. ft.		Gals.
1 : 2 : 4 Concrete ...	1	4	2	7½	8½	2′ × 4′ × 11½″	10
1 : 3 : 6 Concrete ...	1	6	2	11½	12	3′ × 4′ × 11½″	13½

HOW TO MIX CONCRETE.

With the proper materials selected, the next step is to mix properly and with dispatch. On large jobs it is more economical to mix concrete by machine, but for small jobs, using even as much as several hundred cubic yards of concrete, it is much cheaper and more expedient to mix by hand. This is, of course, especially true when only two or three men are available and the work is often interrupted. There are many ways of "hand mixing," all having the same good results. The way described here we believe to be the one best calculated to obtain good results with a minimum of labour. In this description and the accompanying illustrations, we have taken as a basis a "Two-Bag Batch" of 1 : 2 : 4 concrete.

CONCRETE BOARD.

A concrete board for two men should be 9 ft. x 10 ft. Make it out of 1-in. boards, 10 ft. long, surfaced on one side, using five 2 in. x 4 in. x 9 ft. cleats to hold them together. If 1 in. x 6 in. tongue and groove roofers can be obtained, they will do very nicely if fairly free from knots. The object of the surfaced boards is to make the shovelling easy. The boards are so laid as to enable the shovelling to be done with, and not against, the cracks between the boards. The boards must be drawn up close in nailing so that no cement grout will run through while mixing. Knot-holes may be closed by nailing a strip across them on the under side of the board. It is a good precaution against losing cement grout to nail a 2-in. x 2-in. or 2-in. x 4-in. piece around the outer edge of the board. Often 2-in. planks are used in making concrete boards, but these are unnecessarily heavy and very cumbersome to move.

Placing the Concrete Board.—The concrete board is a manufacturing plant, and the advantages of its location should be carefully considered. Generally it is best placed as close as possible to the forms in which the concrete is to be deposited, but "local conditions" must govern this point. Pick a place giving plenty of room, near the storage piles of sand and stone (or pebbles). Block up your concrete board level, so that the cement grout will not run off on one side, and so that the board will not sag in the middle under the weight of the concrete.

RUNS.

Do not use any old boards that are handy for the wheelbarrow runs. Make a good run, smooth, and at least 20 in. wide if much above the ground. It is surprising how this one feature will lighten and quicken the work.

TOOLS AND PLANT.

(For convenience the signs ′ for feet and ″ for inches have been used in describing tools and plant and in Tables I., II., and III.

List of tools and plant to be used in mixing, giving sizes, quantities, etc. :

Concrete Board for 2-Bag Batch, 9′ x 10′ in size.

- 9 pcs. ⅞″ × 12″ × 10″, surfaced one side and two edges. (Any width of plank may be used ; 12″ is specified only for convenience.)
- 5 pcs. 2″ × 4″ × 9′ rough.
- 2 pcs. 2″ × 2″ × 10′ rough.
- 2 pcs. 2″ × 2″ × 9′ rough.

Concrete Board for 4-Bag Batch, 12′ x 10′ in size.

- 12 pcs. ⅞″ × 12″ × 10′, surfaced one side and edges. (Any width of plank may be used ; 12″ is specified only for convenience.)
- 5 pcs. 2″ × 4″ × 12′ rough.
- 2 pcs. 2″ × 2″ × 10′ rough.
- 2 pcs. 2″ × 2″ × 12′ rough.

Runs.—2″, 2½″, or 3″ plank, 10″ or 12″ wide.

Measuring Boxes for Sand and Stone or Gravel.

For 2-Bag Batch 1 : 2 : 4 Mixture :

- 4 pcs. 1″ × 11½″ × 2′ rough.
- 2 pcs. 1″ × 11½″ × 4′ rough.
- 2 pcs. 1″ × 11½″ × 6′ rough.

NOTE.—The 2 pcs. 4′ long and the 2 pcs. 6′ long have an extra foot in length at each end to be made into a handle.

For 2-Bag Batch 1 : 3 : 6 Mixture :

2 pcs. 1″ × 11½″ × 2′
2 pcs. 1″ × 11½″ × 3′
2 pcs. 1″ × 11½″ × 5′
2 pcs. 1″ × 11½″ × 6′

NOTE.—The 2 pcs. 5′ long and the 2 pcs. 6′ long have an extra foot in length at each end to be made into a handle.

For 4-Bag Batch :

Double cubic contents of boxes and order lumber accordingly.

Shovels.—Square point.
Wheelbarrows.—At least two necessary for quick work; sheet-iron body preferred.
Rake.
Water-barrel.
Water-buckets.—2-gallon size.
Tamper.—4″ × 4″ × 2′ 6″, with handles nailed to it.
Garden spade or " spading " tool.
Sand Screen.—Made by nailing a piece of ¼″ mesh wire screen 2½′ × 5′ in size to a frame made of 2″ × 4″.

MIXING.

With the mixing board placed and the " runs " made the concrete plant is ready.

First load your sand in wheelbarrows from the sand pile, wheel on to the " board," and fill the sand-measuring box, which is placed about 2 ft. from one of the 10-ft. sides of the board. When the sand box is filled, lift it off and spread the sand over the board in a layer 3 in. or 4 in. thick. Take the two bags of cement and place the contents as evenly as possible over the sand. Two men start mixing the sand and cement, each man turning over the half on his side, starting at his feet and shovelling away from him. In turning the shovel the materials must be off the end and sides of the shovel, so that the sand and cement are mixed as they fall. This is a great assistance in mixing these materials, as in this way the material is shovelled from one side of the board to the other.

The sand and cement should now be well mixed and ready for the stone and water. After the last turning, spread the sand and cement out carefully, place the gravel or stone measuring box beside it, and fill from the gravel pile. Lift off the box and shovel the gravel on top of the sand and cement, spreading it as evenly as possible. With some experience equally good results can be obtained by placing the gravel measuring box on top of the carefully levelled sand and cement mixture, and filling it, thus placing the gravel on top without an extra shovelling. Add about three-fourths the required amount of water, using a bucket and dashing the water over the gravel on top of the pile as evenly as possible. Be careful not to let too much water get near the edges of the pile, as it will run off, taking some cement with it. This caution, however, does not apply to a properly constructed mixing board, as the cement and water cannot get away. Starting the same as with the sand and cement, turn the materials over in much the same way, except that, instead of shaking the materials off the end of the shovel, the whole shovel load is dumped and dragged back towards the mixer with the square point of the shovel. This mixes the gravel with the sand and cement, the wet gravel picking up the sand and cement as it rolls over when dragged back by the shovel. Add water to the dry spots as the mixing goes on until all the required water has been used. Turn the mass back again, as was done with the sand and cement. With experienced labourers, the concrete would be well mixed after three such turnings; but if it shows streaky or dry spots it must be turned again. After the final turning, shovel into a compact pile. The concrete is now ready for placing.

Mixing Natural Mixture of Bank Sand and Gravel.—Spread out the mixture of sand and gravel as much as the board will readily permit, add enough water to wet the gravel and sand thoroughly, spread the cement evenly in a thin layer over the sand and gravel, and turn over, as described previously, at least three times, adding the rest of the water necessary to get the required consistency while the materials are being turned. It requires some experience to work up a natural mixture of bank sand and gravel, and if at all doubtful about the concrete made from it, first screen the sand from the gravel, and then mix in the regular way.

Number of Men.—For the above operation only two men are required, although more can be used to advantage. If three men are available, let two of them mix as described above and the third man supply the water, help mix the concrete by raking over the dry or unmixed spots as the two mixers turn the concrete, help load the wheelbarrows with sand and stone or gravel, etc.

How to Determine Quantities of Materials Needed.—First figure the number of cubic feet of concrete that will be required for the work in question. Then by multiplying this number by the number under the proper column and required mixture shown in Table III below, the amounts of cement, sand, and stone or gravel can be found.

TABLE III.

Mixture.	Quantities of Material in 1 cu. ft. of Concrete.		
	Cement, Barrel.	Sand, Cu. yd.	Stone or Gravel, Cu. yd.
1 : 2 : 4 Concrete	·058	·0163	·0326
1 : 3 : 6 Concrete	·041	·0174	·0348

Example.—Suppose the work consists of a concrete silo requiring in all 935 cu. ft. of concrete, of which 750 cu. ft. is to be 1 : 2 : 4 concrete, and 185 cu. ft. is to be 1 : 3 : 6 concrete. Also enough sand and cement is needed to paint the silo inside and outside, in all 400 sq. yds. of surface, with a 1 : 1 mixture of sand and cement. One cu. ft. of 1 : 1 mortar will paint about 15 sq. yds. of surface and requires 0·1856 barrel of cement and 0·0263 cu. yd. of sand.

Solution:

CEMENT:	Barrels.
Cement for the 750 cu. ft. of 1 : 2 : 4 concrete is 750 × ·058 ... ... =	43·5
Cement for the 185 cu. ft. of 1 : 3 : 6 concrete is 185 × ·041 ... ... =	7·6
Cement for painting ... ... $\frac{400}{15}$ × ·1856 ... ... =	4·9
Total cement	56·0
SAND:	Cu. yd.
Sand for the 750 cu. ft. of 1 : 2 : 4 concrete is 750 × ·0163 ... ... =	12·25
Sand for the 185 cu. ft. of 1 : 3 : 6 concrete is 185 × ·0174 ... ... =	3·25
Sand for painting ... ... $\frac{400}{15}$ × ·0263 ... ... =	·75
Total sand	16·25
STONE OR GRAVEL:	Cu. yd.
Stone or gravel for the 750 cu. ft. of 1 : 2 : 4 concrete is 750 × ·0326 ... =	24·5
Stone or gravel for the 185 cu. ft. of 1 : 3 : 6 concrete is 185 × ·0348 ... =	6·5
Total stone or gravel	31·0

Thus the necessary quantities of materials are:

56 barrels of Portland cement.
16¼ cu. yds. of sand.
31 cu. yds. of stone or gravel.

It is always wise to order two or three extra barrels of cement, if the dealer is at considerable distance, as this avoids any possible trouble that a shortage might cause. Besides, any cement left over always comes in handy for repair work around the house or barn.

PLACING THE CONCRETE.

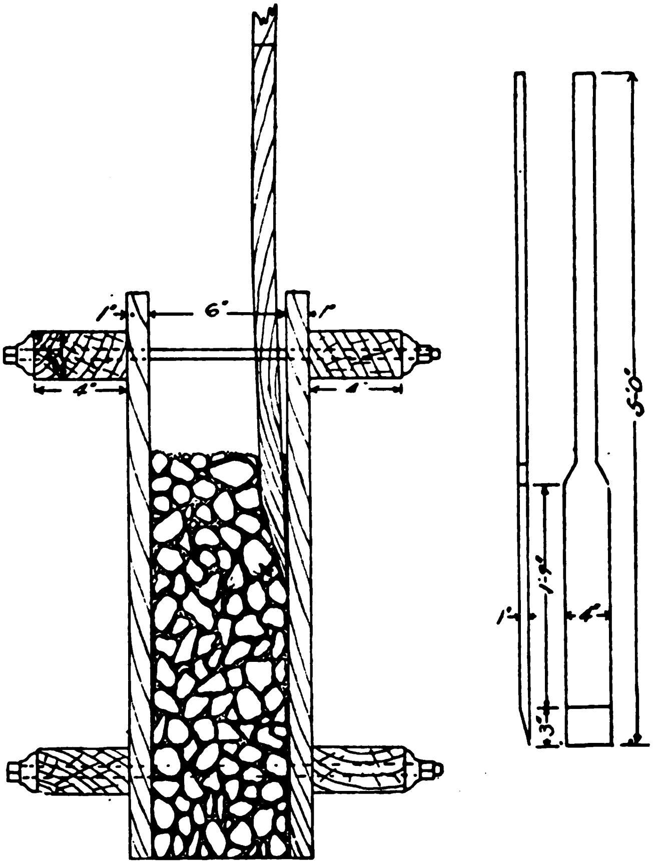
Method of Placing.—After the concrete is properly mixed it should be placed at once. Concrete may be handled and placed in any way, best suited to the nature of the work, provided the materials do not separate in placing. Concrete may be properly placed by shovelling off the concrete board directly into the work, by shovelling into wheel-barrows, wheeling to place and dumping, by shovelling down an inclined chute, or by shovelling into buckets and hoisting into place. Concrete should be deposited in layers about 6 inches thick unless otherwise specified.

CONSISTENCY.—There are three kinds of mixtures used in general concrete work, as follows:

1. *Very Wet Mixture.*—Concrete wet enough to be mushy and run off a shovel when handling. Used for reinforced work, thin walls, or other thin sections, etc.; no ramming necessary.

2. *Medium Mixture.*—Concrete just wet enough to make it jelly-like. Used for some reinforced work, also foundations, floors, etc. Ramming with tamper or treading with feet necessary to remove air-bubbles and fill voids.

3. *Dry Mixture.*—Concrete like damp earth: used for foundations, etc., where it is important to have the concrete set up as quickly as possible. This must be spread out in a 4-in. to 6-in. layer in placing and thoroughly tamped until the water comes to the surface.



SPADING THIN 6-IN. CONCRETE WALL; ALSO SHOWING WOODEN SPADING TOOL.

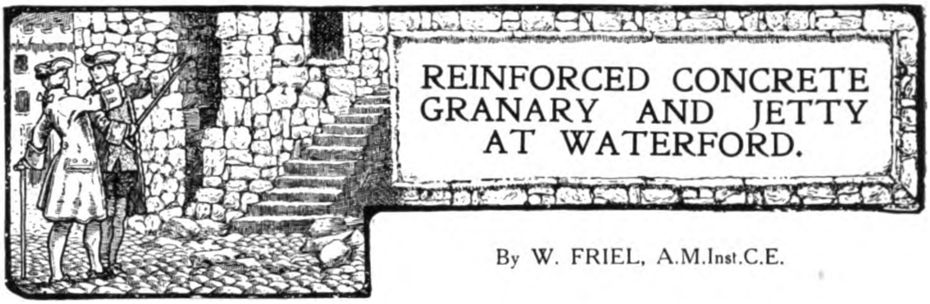
The proper mixture to use for a given operation will always be specified in the subsequent bulletins on construction. The difference between the mixtures is that the drier the mixture the quicker the concrete sets up; in the end when carefully mixed and placed the results from any of the above mixtures would be the same. A dry mixture, however, cannot be used readily with reinforced steel, costs more and is harder to handle, must be protected with greater care from the sun or from drying too quickly, and, lastly, is likely, unless "spaded" by most experienced hands, to show voids or stone (or gravel) pockets in the face of the work when the forms are removed.

SPADING.—Concrete of any of the three degrees of consistency mentioned above should be carefully " spaded " next to the form where the finished concrete will be exposed to view. " Spading " consists of running a spade or flattened shovel down against the face of the form and working up or down. This action causes the stone or gravel to be pushed back slightly from the form, and allows the cement grout to flow against the face of the form and fill any voids that might be there, thus making the face of the work present an even, homogeneous appearance. Where the narrowness of the concrete section, such as in a 6-in. silo wall, prevents the use of a spade, a 1-in. by 4-in. board, sharpened to chisel edge on the end, will do as well. Only sharpen on one side and place the flat side against the form as shown in illustration. In the case of a dry mixture, " spading " must be done with greatest care by experienced hands to get uniform results, but with a medium or wet mixture it is very easy to obtain first-class work; indeed, with a wet mixture spading is only required as an added precaution against the possibility of voids in the face of the work, and is really necessary in few cases.

Protection of Concrete after Placing.—Green concrete should not be exposed to the sun until after it has been allowed to set for five or six days. Each day during that period the concrete should be wet down by sprinkling water on it, both in the morning and afternoon. This is done so that the concrete on the outside will not dry out much faster than the concrete in the centre of the mass, and should be carried out carefully, especially during the hot summer months. Old canvas, sheeting, burlap, etc., placed so as to hang an inch or so away from the face of the concrete will do very well as a protection. Wet this as well as the concrete. Often the concrete forms can be left in place a week or ten days; this protects the concrete during the setting-up period and the above precautions are then unnecessary.

Cleaning the Concrete Board.—When the day's work is done, carefully clean all the tools, especially the concrete board. Remove with a shovel all the loose cement, sand, and stone. Then scrub the board with a broom and water. If this is not done, small particles of stone are glued to the board by the cement, and render shoveling the next day most difficult.

In closing, we again wish to call attention to the fact that there are several ways of buying cement, storing cement, and mixing concrete by hand, just as effective in their results as the ways mentioned here. But every man of experience in mixing has one way which he thinks is more effective and easier than any other. The way described here is *our* easy way.



REINFORCED CONCRETE GRANARY AND JETTY AT WATERFORD.

By W. FRIEL, A.M.Inst.C.E.

Of the many purposes to which reinforced concrete can be economically applied, few are more suitable than granaries, silos, etc. For jetties, too, this material is exceptionally well adapted.

The instances here described bear out our contention.—ED.

THE two structures described in this article are situated on the northern bank ot the River Suir at Waterford, and form an extension of the establishment founded many years ago by the firm of R. & H. Hall, Ltd.

The granary building is 125 ft. 6 in. long by 52 ft. wide by 85 ft. high from ground level to the parapet of the flat roof, and provides accommodation for the storage of 30,000 quarters of grain, representing a load of 6,500 tons. The building is equipped with the most modern types of conveying and elevating plant, operated electrically. The generating plant consists of two 75 H.P. National gas suction plants and engines. The building is lighted by electricity, and the entire electric, conveying and elevating plant was supplied and fixed by Messrs. Spencer & Co., Ltd., Melksham.

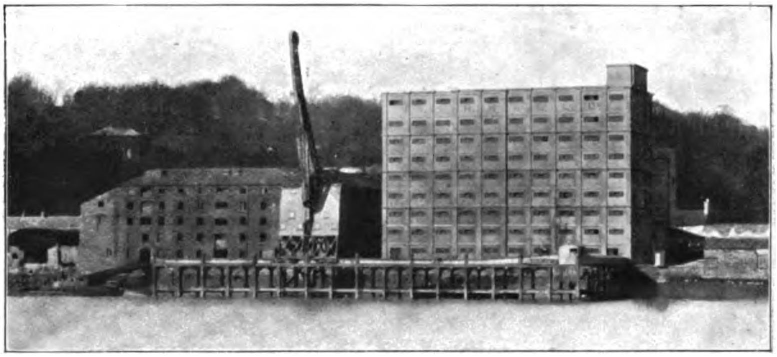


FIG. 1. GENERAL VIEW OF GRANARY AND JETTY AT WATERFORD.

The jetty, built in front of the granary, is 200 ft. long by 22 ft. wide, and is connected with the river quay by two approach jetties each 68 ft. long by 12 ft. 6 in. wide. The jetty proper is provided with a 100-ton per hour travelling elevator, running along a 16 ft. 6 in. gauge track, and being situated in deep water, permits vessels of large size to be moored alongside for the discharge of cargo.

Fig. 1 is a general view of the establishment from the river, and will enable the reader the better to follow the subjoined description of structural features and details.

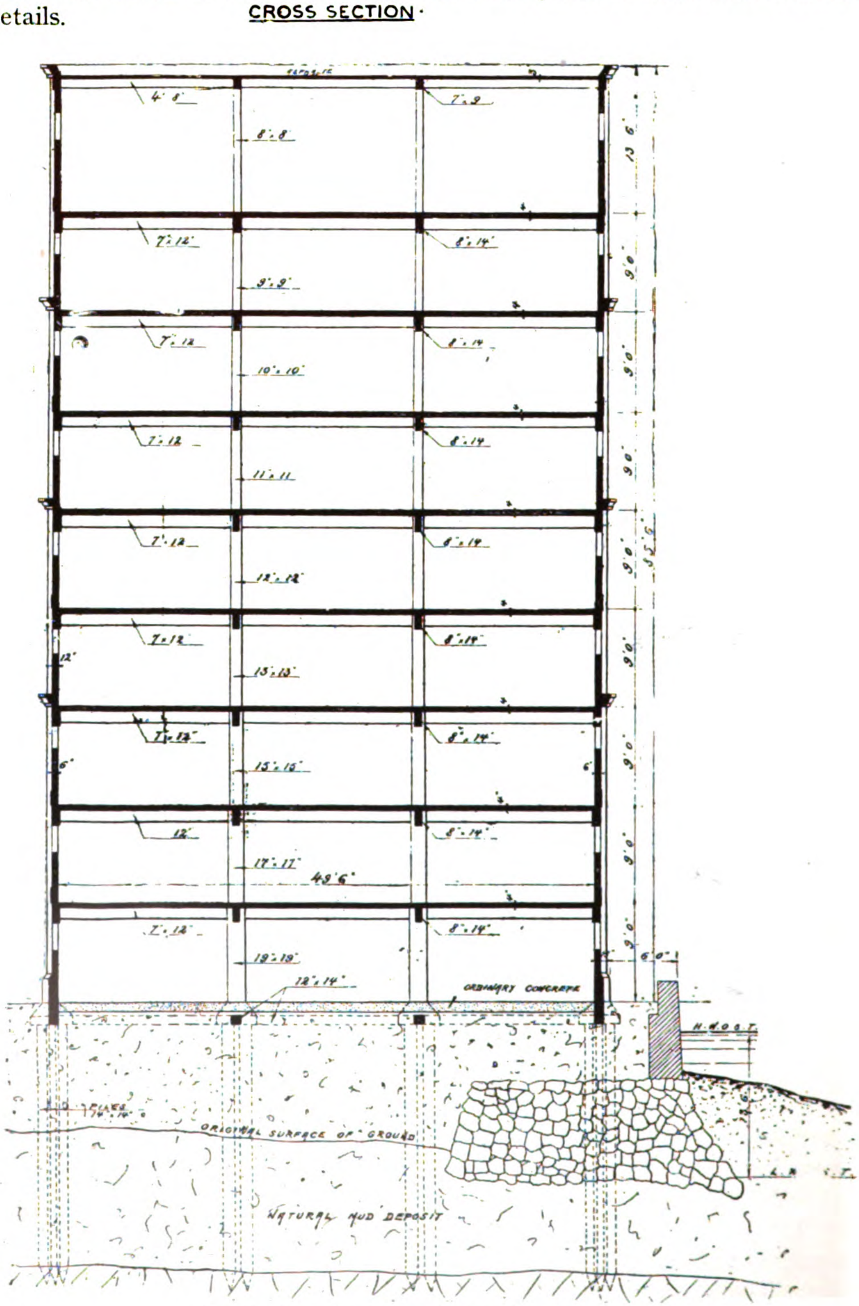


Fig. 2. Cross Section of Granary Building.

GRANARY BUILDING.

Fig. 2 contains a cross section, showing that the front of the granary is only 6 ft.

from the face of the river wall. The original surface of the site was 10 ft. below high water level and, after reclamation, was brought up to the height of 3 ft. above high water level by filling, the filling being retained by a quay wall resting on a rubble mound foundation; below the filling there is a layer of mud to the depth of about 12 ft., then a compact bed of 6 ft. of stiff marly clay overlying the rock.

All loads are transmitted by a series of 44 main columns, the bases of which are carried by groups of Hennebique piles driven through made ground and mud into firm soil.

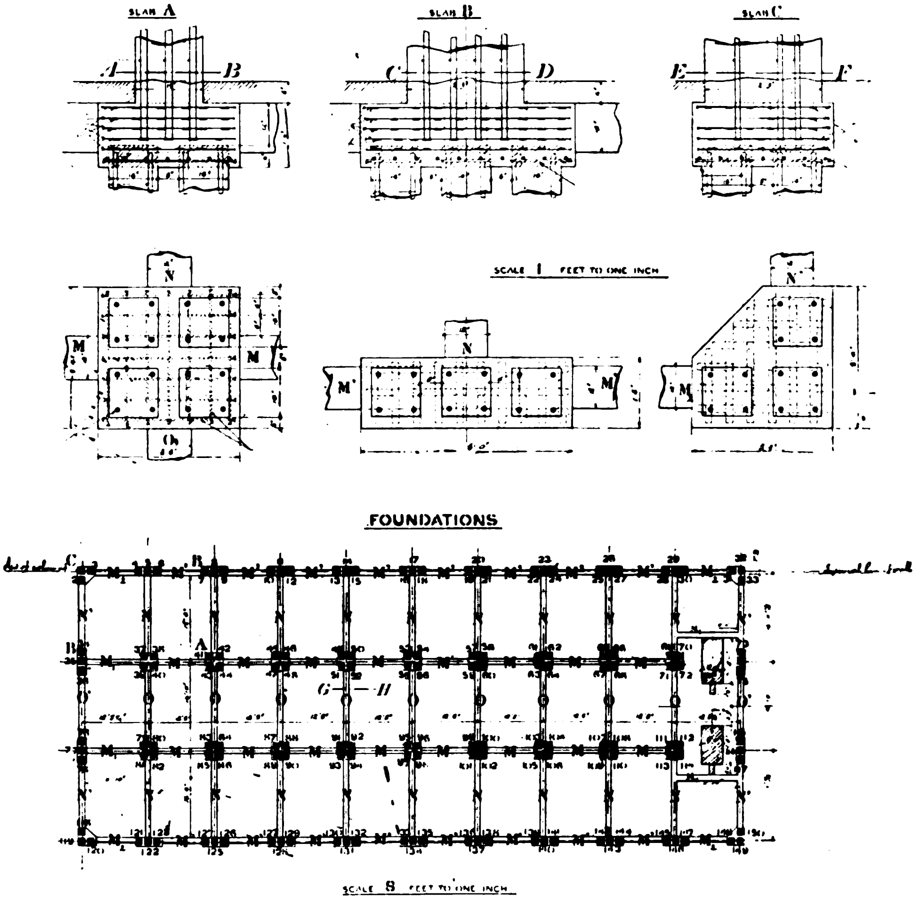


Fig. 3. Foundation Plan of Granary, with Details, Plans and Sections of Slabs.

On *Fig.* 3 is a foundation plan showing the piles in section. All these members are 14 in. square, reinforced longitudinally and transversely. They are arranged in groups of four for the interior columns, in triangular groups of three for exterior corner columns, and in parallel groups of three for intermediate exterior columns.

After having been driven to refusal, the piles were trimmed off to uniform level and the concrete stripped so as to leave the longitudinal bars of the reinforce-

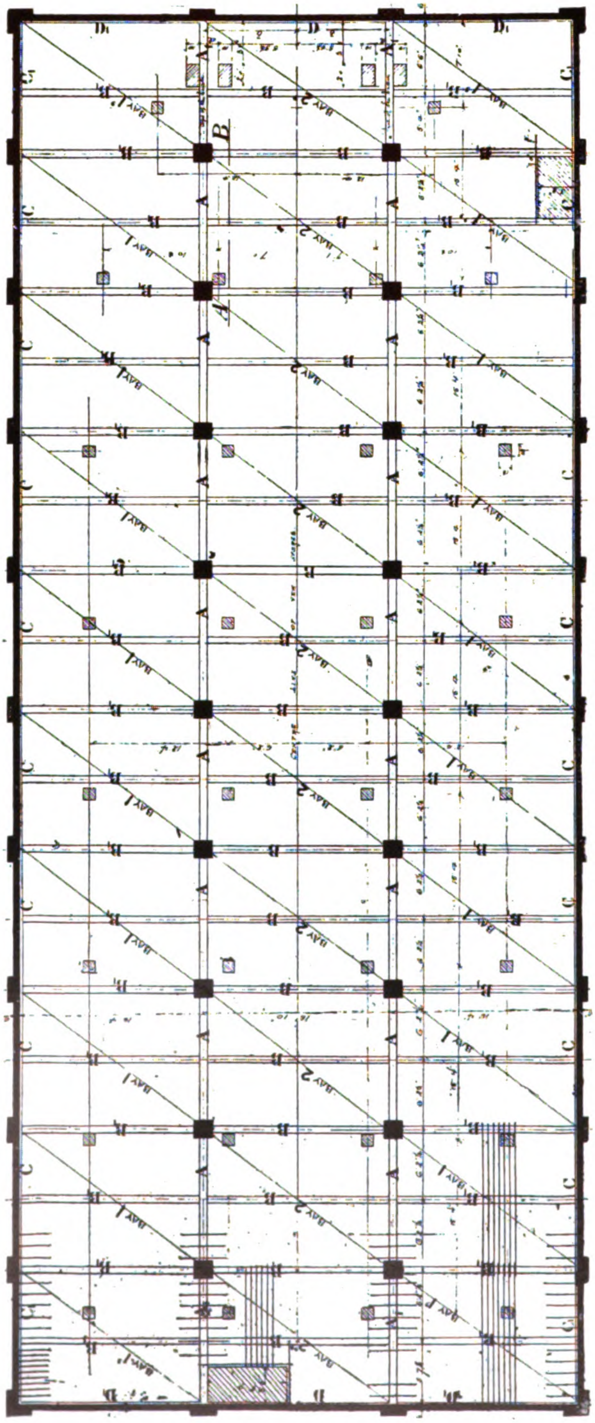


Fig. 4. Plan of First Floor, Granary Building.

ment to project for incorporation in the connecting slabs, thus insuring proper anchorage of the bars. The arrangement of the piles necessitates three different forms of slabs: A for interior columns; B for intermediate exterior columns; and C for corner columns. Details of these slabs are also shown on page 655.

The plan of slab A (*Fig.* 3), shows the four piles driven 6 in. apart, each reinforced by four 1¼-in. longitudinal bars and connected at the head by a concrete slab 3 ft. 4 in. square by 1 ft. 6 in. deep, reinforced by six tiers of bars and hoop steel in two series forming network with square meshes.

Near the bottom of the slab the network consists of seven ½-in. diameter bars, 3 ft. 2 in. long in one direction, and seven bars of the same size and length at right angles. The five upper sets of network each consist of two series of seven strips of hoop steel, 2 in. wide by No. 12 S.W.G., disposed at right angles, as in the case of the bars.

Into the reinforced concrete slab are carried

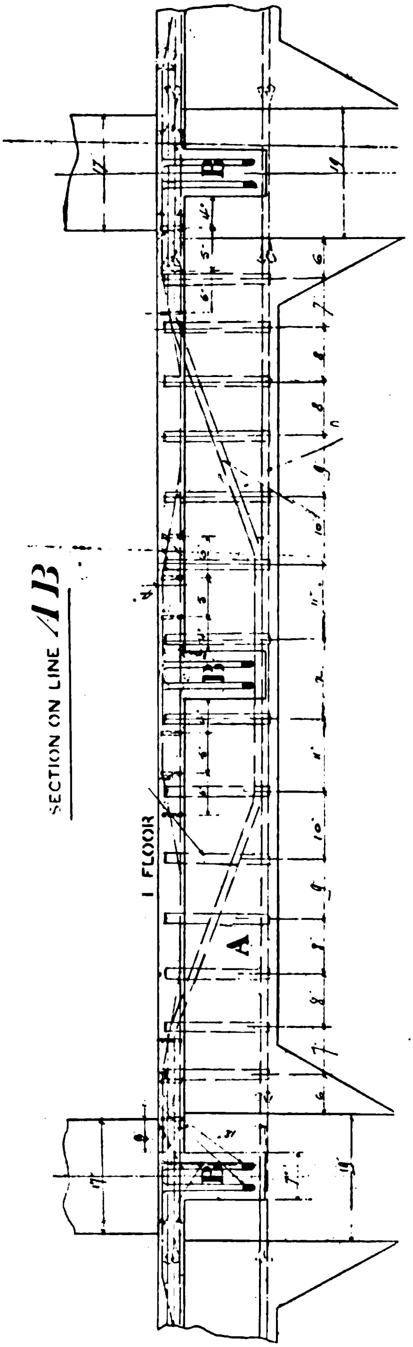


Fig. 5. Details of First Floor Construction.

the main longitudinal reinforcing bars of the main column. The bars take bearing upon the reinforced concrete by which the load is distributed and transmitted to the piles. As the concrete of the piles, the slab, and the column is monolithic throughout, the three elements are effectively combined to form a single unit, and it may fairly be said that each column virtually commences at the point of the piles, extending thence in an unbroken line to the top of the building.

In slab B (*Fig.* 3) we find an essentially similar disposition of the reinforcement, the only difference being that the piles are arranged in a series of three to suit the oblong-shaped intermediate columns.

The slab C (*Fig.* 3) is formed suitably for the L-shaped corner columns, while the method of construction remains virtually identical in principle with that already described.

All the column bases are connected longitudinally and transversely by reinforced concrete struts 12 in. wide by 14 in. deep. The reinforcement comprises four ⅞-in. diameter longitudinal bars and 3/16-in. diameter steel wire links in four sets, binding the main bars securely in every direction.

Fig. 4 is a typical floor plan, viewed from the underside. Apart from the wall lintels, the construction consists of main beams, secondary beams, and a floor slab continuous in every direction. We will deal briefly with each of these elements in turn.

The main beams, measuring 8 in. wide by 14 in. deep, extend longitudinally from column to column. They are reinforced by four 1-in. diameter bars, two straight and two bent up towards the supports, to provide for negative tension and tension on diagonal planes, resulting from shearing stress and flexure, and they also include auxiliary reinforcement in the form of U-shaped stirrups of hoop steel at frequent intervals.

The secondary beams, measuring 7 in. wide by 12 in. deep, are of two classes viz., those supported by main beams and those carried directly by the columns. All these are reinforced in the same way as the main beams, and both series are connected by the continuous floor slab, 4 in. thick, which acts as a general compression flange. The slab is reinforced in two directions by bars of $\frac{7}{16}$-in. diameter, alternately straight and bent up over the supports, as well as by stirrups for resistance to shear and diagonal tension.

The tension and web reinforcement of the main and secondary beams passes within the slab, thereby making efficient connection between all elements of the floor construction.

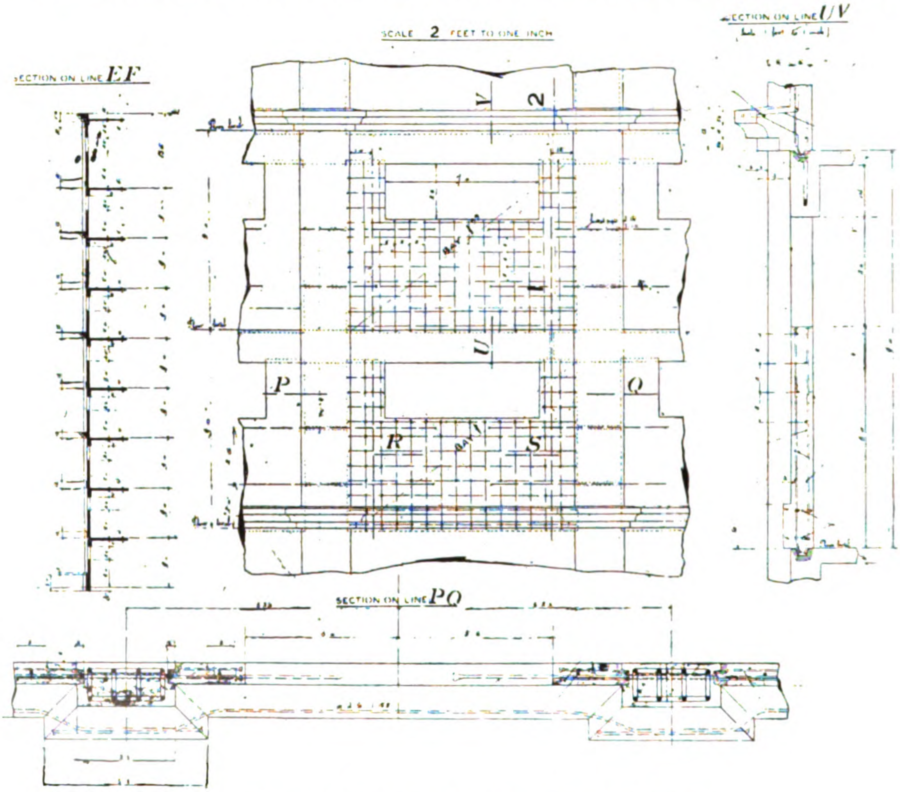


Fig. 6. Details of Wall Construction of Granary Building.

The floor system is completed by the wall lintels extending from column to column ; these lintels also carrying the weight of the wall panels.

Fig. 5 gives details of the construction described above, which applies to all suspended floors throughout the building, the calculated superload being $2\frac{3}{4}$ cwt. per sq. ft.

No essential difference is shown in the design of the flat roof, except that the main and secondary beams and connecting slab are of smaller dimensions conformable with the reduced superload of 5 cwt. per sq. yd. The main beams measure 7 in. wide by 9 in. deep, the secondary beams are 4 in. wide by 8 in.

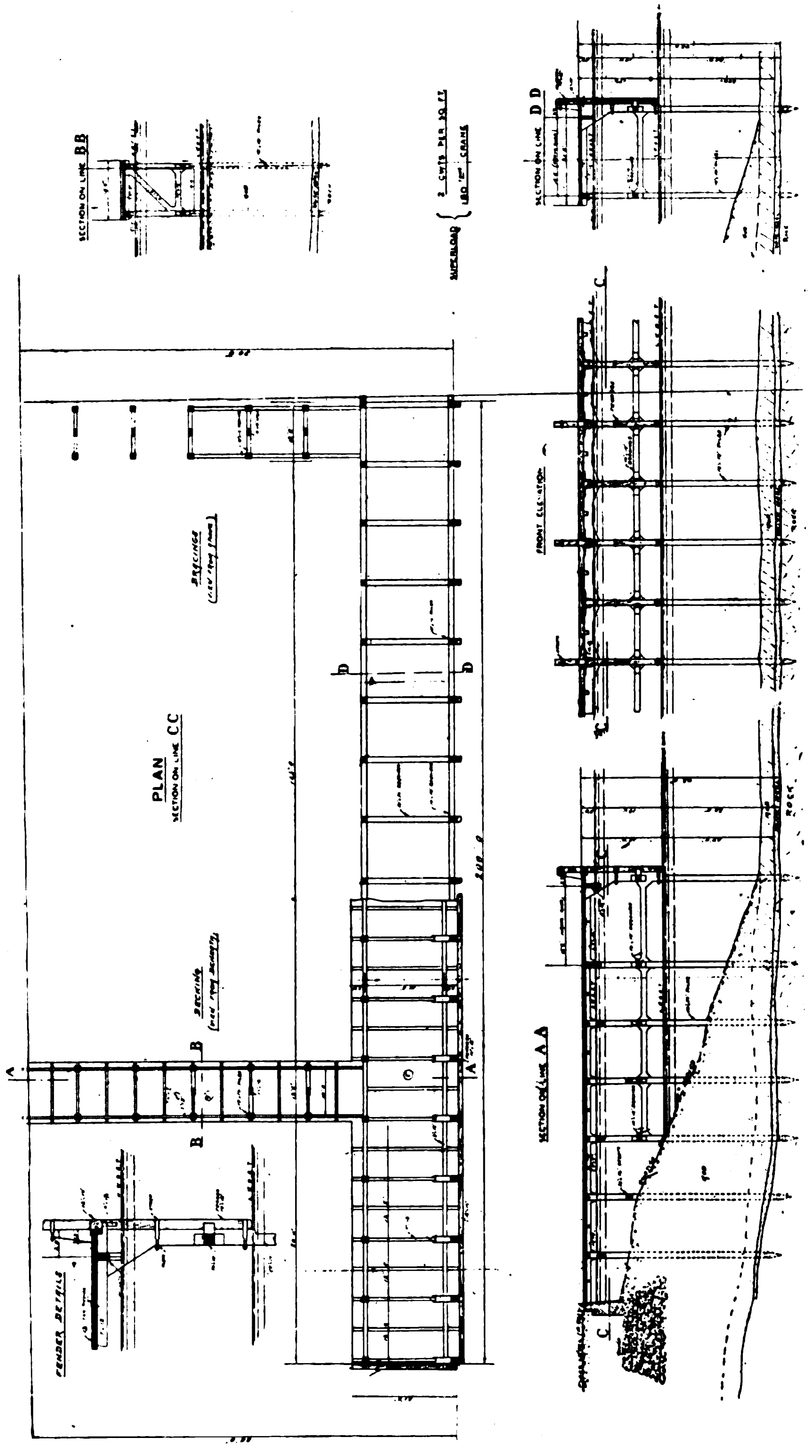


FIG. 7. PLAN, SECTIONS AND ELEVATION OF JETTY.

deep, and the slab is 3 in. thick, the latter being covered with asphalte as an additional precaution against the penetration of moisture.

Fig. 6 contains a number of details reproduced from working drawings for the wall construction on the side fronting the river. The small section at the left hand shows the nine storeys of the building in outline, the next figure being an elevation partly in section of two wall bays at seventh and eighth storey levels. The wall panels between the columns and lintels are 6 in. thick, reinforced by a double network of $\frac{5}{16}$-in. diameter rods, connected by U-shaped stirrups, and at intervals of 2 ft. 6 in. apart vertically, longitudinal tie bars of $\frac{3}{4}$-in. diameter are inserted. Further details are represented in section P—Q, showing two of the wall columns, portions of the curtain walls and part of the projecting cornice.

Figs. 8 and 9 are two interior views showing the facility offered by reinforced concrete for the installation of mechanical plant and electrical equipment.

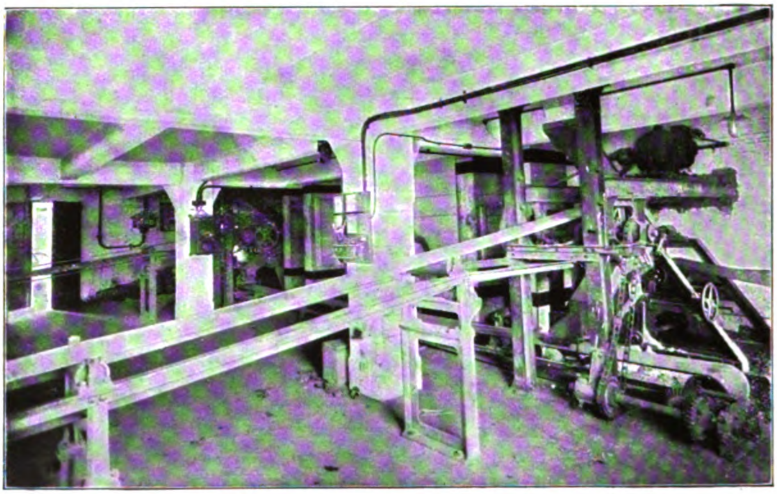


Fig. 8. Interior of Granary, showing Plant.

The exterior of the granary was plastered, the columns, string and cornices in plain cement plaster, and the panels in dashed cement work; the mouldings to cornice and projecting strings were cast *in situ*. The interior of the walls received one coat of cement plaster. The wearing surface of the floors was composed of 1 in. of 2 to 1 cement concrete. The columns, beams and underside of floor slabs were not treated, but stand as they stripped from the moulds.

THE JETTY.

The position of the jetty is indicated by *Fig.* 1, a general plan being given in *Fig.* 7, the left-hand half showing the deck construction viewed from beneath, and the right-hand half representing the substructure viewed from above. The substructure consists of fifty-four Hennebique piles, with the average length of 34 ft. driven into the river bed. The piles are 14 in. square, connected by main bracing members, and, above these, columns are continued up for supporting the main and secondary beams of the decking.

A section on the line A—A is also shown in *Fig.* 7, making clear the structural details of the jetty. The foundation piles are driven through mud and a thin layer of white marl into solid rock, at the average depth of about 40 ft. below quay level, the waterway being 22 to 24 ft. deep at low water and 35 to 38 ft. deep at high water.

In the front portion of the jetty the main bracing members are 14 in. square, and the joints between them and the piles are strengthened by gussets of reinforced concrete. To impart increased rigidity to the front of the jetty the columns are made 20 in. deep by 14 in. wide, and near the top are extended to the depth of 4 ft. 9 in. As shown in *Fig.* 7, the main beams of the decking are similarly enlarged at the end of each span, thereby constituting an exceptionally rigid framework, which is further stiffened by the secondary beams and continuous deck slab.

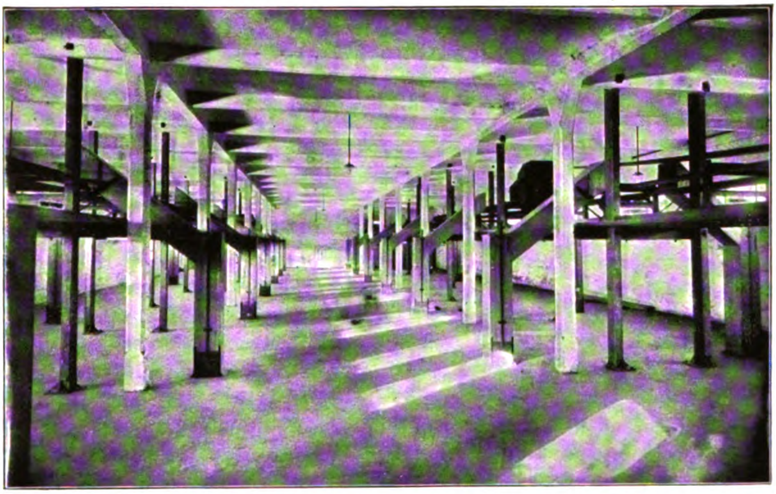


FIG. 9. INTERIOR OF GRANARY BUILDING.

For the protection of vessels, the front of the jetty is sheathed by timber fenders 14 in. by 12 in., secured by steel straps, as represented in the detail at the left hand of *Fig.* 7.

In the two approach jetties the bracing members measure 10 in. by 12 in., and the same general method of construction is followed.

The crane road extends for the full length of the jetty proper, the two rails being situated over the main longitudinal beam. The crane represents a moving load of 180 tons, without taking into account the weights lifted, and the decking throughout was calculated for distributed load of 2 cwt. per sq. ft.

Both of the structures described were designed by Mr. W. Friel, A.M.Inst.C.E. They were built by the Yorkshire Hennebique Contracting Co., Ltd., of Viaduct Works, Leeds.

TESTS OF REINFORCED CONCRETE BEAMS UNDER REPEATED LOADING.

The systematic series of tests with reinforced concrete conducted in the United States claims the attention of all concerned with the subject, no matter where located. We are, therefore, presenting from time to time summaries of these tests, and the contribution below we hold to be a very valuable one.—ED.

THE tests referred to below were undertaken in the Materials Testing Laboratory of the University of Pennsylvania by H. C. Berry, with the assistance of Mr. A. T. Goldbeck, Instructor in Civil Engineering. The tests first referred to took place in 1908. Later the tests undertaken in 1909 are referred to. They had for their object the study of the effect of a great number of repetitions of working loads on the strength and elastic properties of reinforced concrete beams. For this purpose the beams were made in duplicate. One was subjected to many thousand repetitions of a load sufficient to cause stresses somewhat greater than are allowed in good practice, and then tested to failure, the load being applied and released several times after each increment was added. The duplicate beam was tested to failure in the usual way by students as a part of their regular laboratory work. The load was released but once or twice in these tests.

The beams were standard 8-in. by 11-in. by 13-ft. beams. They differed only in the kind and amount of the reinforcing steel. Plain and deformed steel was used. Table I. gives the results of tests on the steel.

TABLE I.—TESTS OF STEEL IN BEAMS.

Bar.	Yield Point. Lbs. per sq. in.	Ultimate Strength. Lbs. per sq. in.	Elongation in 8 ins.	Reduction of Area.
Corrugated	48,000	81,600	16%	20%
Diamond	53,000	88,000	17%	24%
Plain	38,000	56,000	33%	60%

The concrete was made in 1 part Portland cement, 1½ parts bar sand, and 4½ parts of crushed granite passing a ¾-in. sieve. This proportion gave greater density and strength for these materials than the more usual 1 : 2 : 4. The concrete was mixed medium wet and troweled into place by hand without the use of heavy rammers. The mould was removed in from one to three days and the beam covered with damp sawdust. Table II. gives data from tests of cubes made from four of the mixes.

TABLE II.—TESTS OF SIX-INCH CUBES.

Concrete from Beam No.	No. of Cubes.	Age, Weeks.	Average Ultimate Strength. Lbs. per sq. in.	Extreme Variation.
2	3	6	2,600	14%
3	3	6	2,290	3%
6	2	6	2,350	4%
7	2	6	2,670	1%

The average ultimate strength of all cubes tested was 2,460 lb. per sq. in. Tests of five cylinders 8 in. in diameter and 16 in. long gave at six weeks an ultimate strength of 1,630 lb. per sq. in. The initial modulus of elasticity was less than 1,000,000 lb. per sq. in.

With two exceptions all beams were tested to failure at six weeks. Those subjected to repeated loading were placed on the apparatus at four weeks and given from 200,000 to 400,000 applications of a load, varying from 4,000 lb. to 6,000 lb. for the different beams. They were then tested to failure that the results might be compared with those of the beams allowed to harden for the full six weeks without being disturbed. The last beam tested received about 1,140,000 applications of the load and was not tested to failure till about eight weeks old.

As shown in *Fig.* 1, the apparatus for the repetition of the load consisted of a pair of proving levers, special bails for the weights, a frame on which were connections to a wrist pin attached to a brick rattler to raise and lower the weights, and a reinforced concrete base to support the beam under test and to develop the reactions. The bails were so attached to the levers as to permit of lifting one while the other rested permanently on the lever. This gave control of the maximum and minimum pressures.

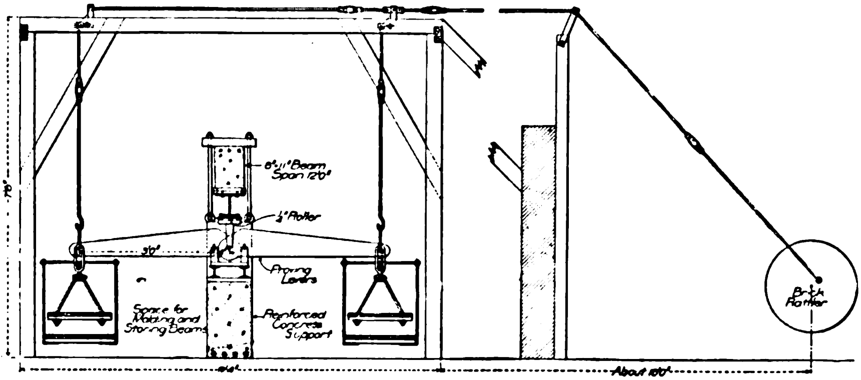


Fig. 1. End view of machine for repeated applications of load to Reinforced Concrete Beams.

The beam under test was placed on the apparatus tension side up. This was of material advantage in making examinations for hairline cracks. The load was applied at the third points of the span, which gave zero shear and uniform bending moment over the middle third of the beam where the fibre extensometers were attached. The load in Table III. and in the diagrams refers to the load applied and released by the moveable bails, the beam and the attached apparatus being supported by the uplift due to the weights in the outer bails which rested permanently on the levers.

The effects of momentum in the application of the load were avoided. Thirty repetitions per minute were made throughout the tests. No attempt was made to determine the effect of varying the rate. The extreme movement of the levers, the deflection of the beam, and the fibre deformations as observed on dial extensometers temporarily attached were the same when the apparatus was running 30 r.p.m. as when it was moved very slowly by hand. The number of applications was recorded by a revolution counter. The numbers on the diagrams are the readings on the counter and not the number of repetitions between plotted readings.

Micrometer screw apparatus reading to 0·0001 in. was used to measure the fibre deformations over a 24-in. gauge length in the plane of the steel and in a plane 1 in. below the surface of the concrete on the compression side of the beam. No temperature corrections have been made in computing unit deformations. Readings of temperature at the time of observing the deformations for May and part of June showed a mean variation of less than 2° F.

The quite noticeable effects of the repetitive loading are best studied on the diagrams, *Figs.* 2 to 4, but Table III. certainly indicates that the ultimate strength and maximum deflection are little affected by repeated loading to the extent to which these tests were carried.

TABLE III.—Summary of Tests Showing Maximum Loads and Deflections.

Beam No.	Reinforcement.	Repetition Test.				Ultimate Load.	Maximum Deflection.
		Total Load.	Unit-Stress. Lbs. per sq. in.		No. of Applications.		
			Steel.	Concrete.			
		lbs.				lbs.	ins.
1	3 plain rods, ¾ in. diam....	*	—	—	200,000	15,900	—
2	4 ,, ,, ½ ,, ,, ...	5,070	18,300	785	297,000	12,300	0·48
3	4 ,, ,, ½ ,, ,, ...	—	—	—	2	12,000	0·56
4	3 Cor. bars, ¾ ,, ,, ...	5,970	10,800	940	295,000	17,000	0·55
5	3 ,, ,, ¾ ,, ,, ...	—	—	—	1	20,000	0·66
6	2 plain rods, ⅝ ,, sq. ...	4,170	15,200	628	395,000	10,500	0·46
9†	2 Diam. bars, ¾ ,, diam....	4,170	14,300	785	718,000	—	—
		5,070	17,100	940	422,000	13,600	0·78
10	2 ,, ,, ¾ ,, ,, ...	—	—	—	3	13,000	0·62

* From 2,370 to 5,970 during the adjustment and trying out of the apparatus.

† After 718,000 applications of 4,170 lbs., the load increased to 5,070 lbs., and the test continued.

No duplicate to Beam 6 was made. Beam 1 was used in trying out the apparatus and was not subjected to the same load throughout the test. It failed in diagonal tension.

The deflection diagrams show an increase in the deflection for the same load as the number of repetitions is increased. The elastic deflection of any beam for a definite load remains nearly constant, but there is an increase in the permanent set. The greater part of this set occurs on the first application and release of the load.

In case of Beam 9, for example, 62,000 repetitions of 4,170 lb., increased the set in the deflection from 0·04 in. to 0·08 in., while the duplicate beam, No 10, had 0·05 in. set on the release from the first application of 5,000 lb. Then 654,000 more applications of 5,070 lb. on Beam 9 increased the set from 0·08 in. to 0·14 in. and 282,000 more applications of 5,970 lb. increased it to 0·16 in.

For Beams 2, 4, 6, and 9, at least one-third of the set present after from 300,000 to 1,000,000 repetitions had occurred before the first 10,000 had been made. No doubt the greatest part of this was due to the first few loadings; for instance, in the case of Beam 4 six applications of the load gave one-fourth as much set as 390,000 later applications of the same load.

While it is evident that the rate of increase in the set is relatively very large for the first few applications of the load, there is nothing to indicate that for a working load the set would cease to become greater. In a paper read before the Society last year, Professor W. K. Hatt reported the same phenomena for deflection under repeated loading. Professor Van Ornum's tests, published in the 1907 " Proceedings " of the American Society of Civil Engineers, show a similar increase in the set under repetitive loading. He worked with greater stresses and obtained a greater rate of increase.

Hairline cracks became visible on the first few applications of working loads. They formed at intervals of from 6 in. to 8 in. along the beam. Examinations with a reading glass were made from time to time, and the depths of the cracks marked. In some instances a crack could be traced 2 in. to 3 in. deeper on one day than on the preceding, but usually the change in depth was small. Some cracks did not become visible till after a great number of applications had been made. None of them extended deeper than the neutral axis of the beam for repetitions of working loads.

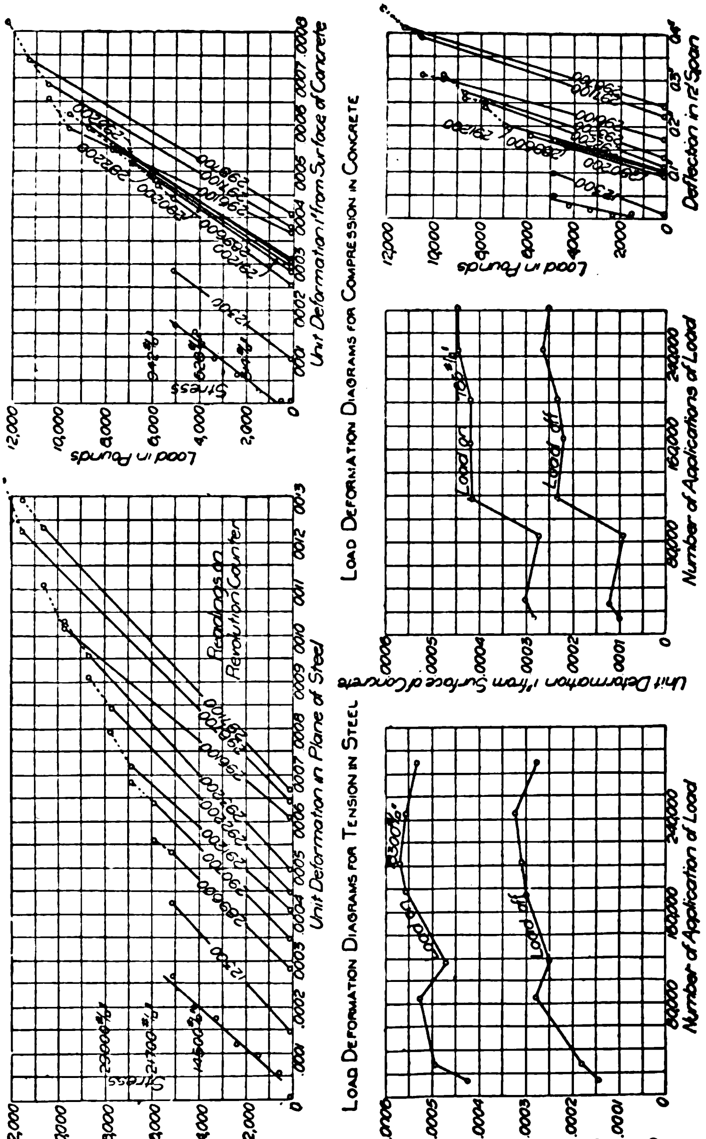


FIG. 2. RESULTS OF TEST ON BEAM NO. 2.

The diagrams for deformation in the plane of the steel also show a permanent set which is greatest for the first few applications of the load. This set did not increase after the first few thousand applications of the load in the case of three of the beams, viz., No. 6, reinforced with three plain bars ⅝ in. square, No. 4, with three corrugated bars ¾ in. square, and No. 9, with two diamond bars ¾ in. in diameter. The set did increase throughout the test in the case of Beams 2 and 8. For Beam 2, reinforced with four plain rods ½ in. in diameter, the set after 290,000 repetitions was about twice as great as at 10,000, but it was then about the same as for the other beams subjected to a corresponding stress.

The beams tested to failure under continuous loading show about one-half as much set in the deformation in the plane of the steel for one application and release of a working load as the beams subjected to many thousand applications of a similar load. The set in the latter case was usually about one-half the total deformation at failure of the beams. This set may be due in part to a set or initial slip in the bond, but there were no indications of any material weakening of the bond when the beams were broken up for removal from the laboratory.

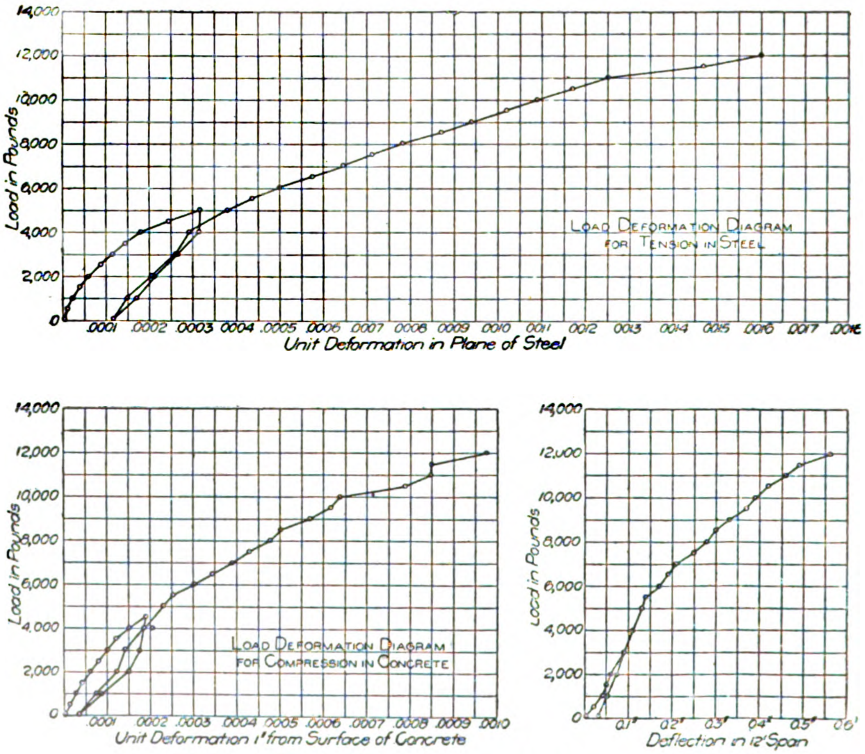
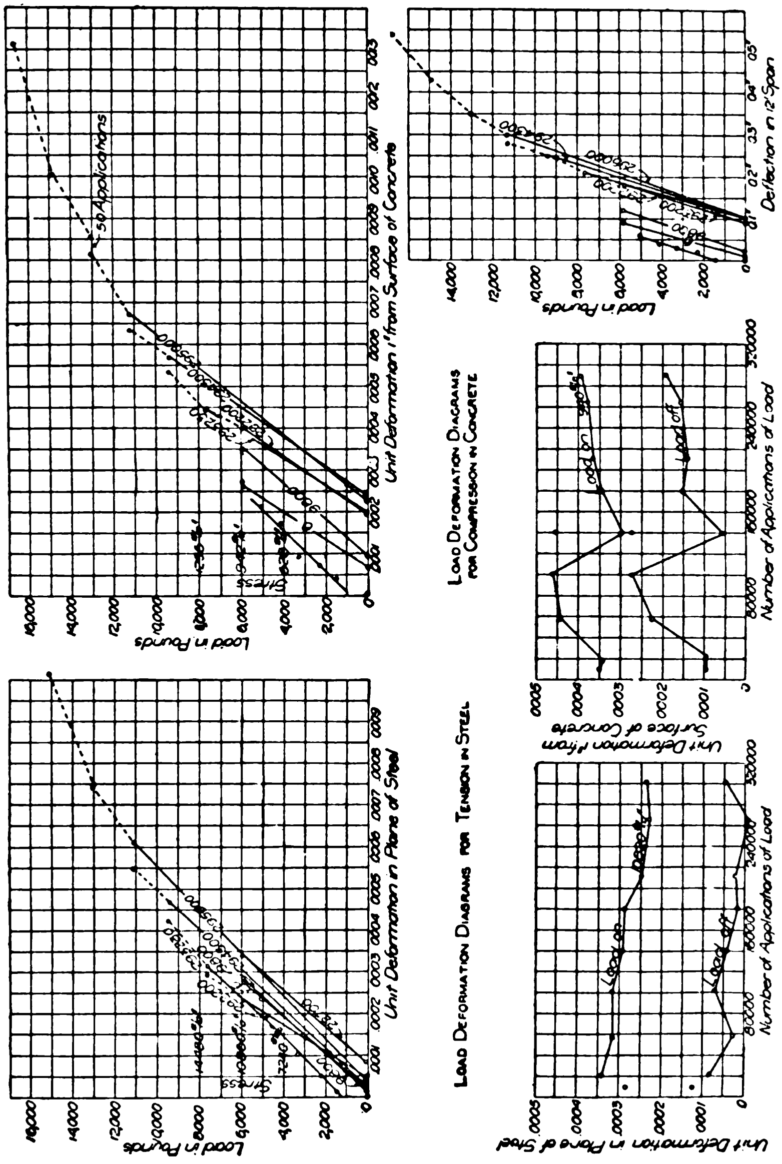


FIG. 3. RESULTS OF TEST ON BEAM NO. 3.

The load-deformation diagrams for the compression side of the beams show the same characteristics as were noted in the case of the deflections. The effect on the set is greatest for the earlier loadings, but as with the deflections the set increases directly with the stress and the number of repetitions, as is shown by the inclination of the "Load On" and Load Off" curves. Table IV. is derived from the slopes of lines drawn on the curves averaging the observed points.

TABLE IV.—RELATION OF REPEATED STRESS TO INCREASE IN SET.

Beam No.	Stress Repeated in the Concrete.	Increase in Set per 00,000 Repetitions.
6	628	0·000014
2	785	40
4	942	50
9	785	32
9	942	40

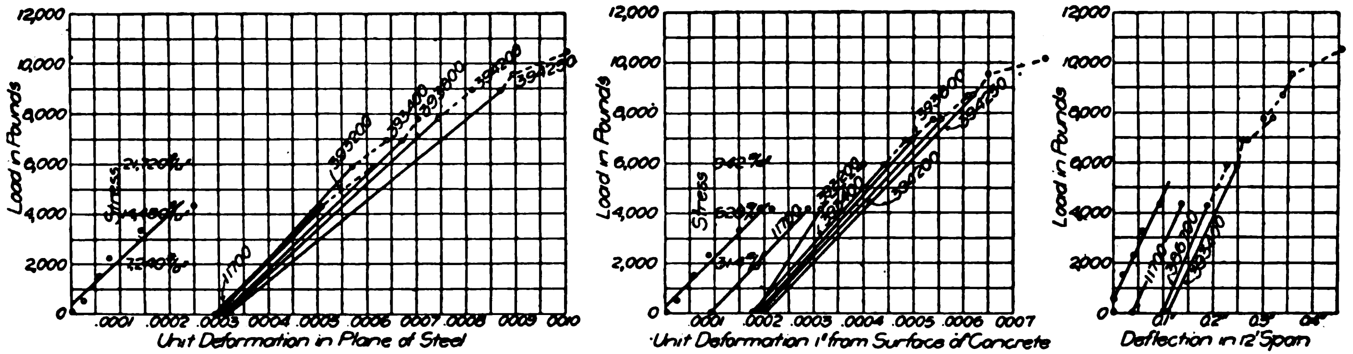


LOAD DEFORMATION DIAGRAMS FOR COMPRESSION IN CONCRETE

LOAD DEFORMATION DIAGRAMS FOR TENSION IN STEEL

FIG. 4. RESULTS OF TEST ON BEAM NO. 4.

The above does not include the initial set from the first 10,000 applications, which was usually about one-half as great as the set after from 200,000 to 400,000. Beam 9



LOAD DEFORMATION DIAGRAMS FOR TENSION IN STEEL

LOAD DEFORMATION DIAGRAMS FOR COMPRESSION IN CONCRETE

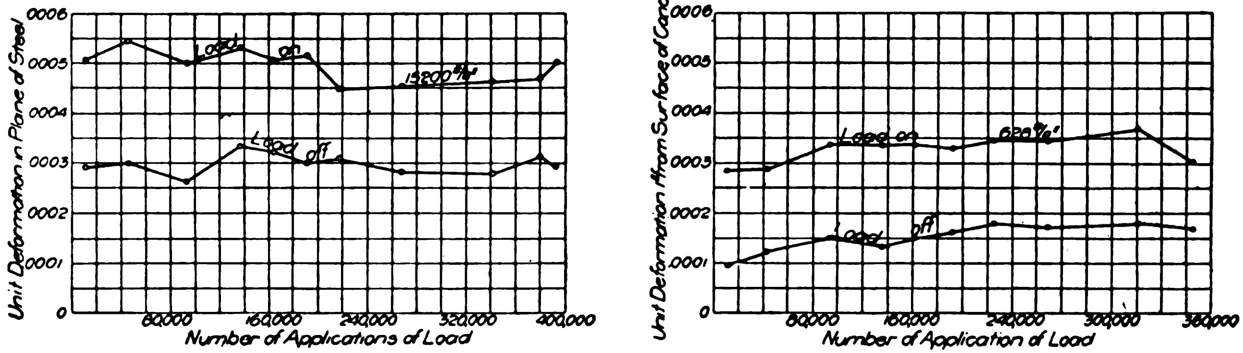
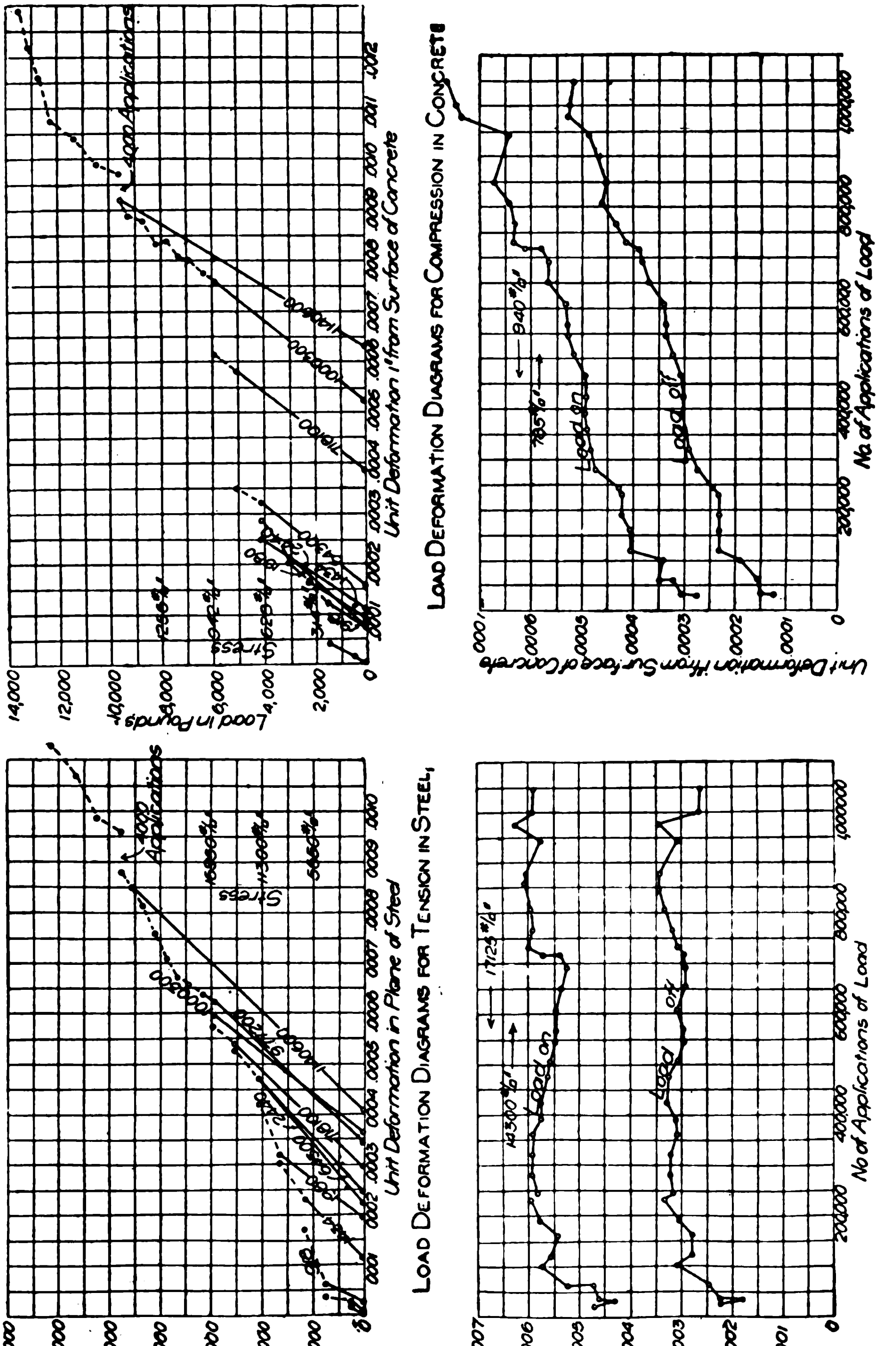


FIG. 5. RESULTS OF TEST ON BEAM NO. 6.



LOAD DEFORMATION DIAGRAMS FOR TENSION IN STEEL.

LOAD DEFORMATION DIAGRAMS FOR COMPRESSION IN CONCRETE.

FIG. 6. RESULTS OF TEST ON BEAM NO. 9.

had at 1,000,000 repetitions about four times the set present at 10,000. The total amount of the progressive set for this high stress, 940 lb. per sq. in., was somewhat less than one-half the total deformation at failure of the beam.

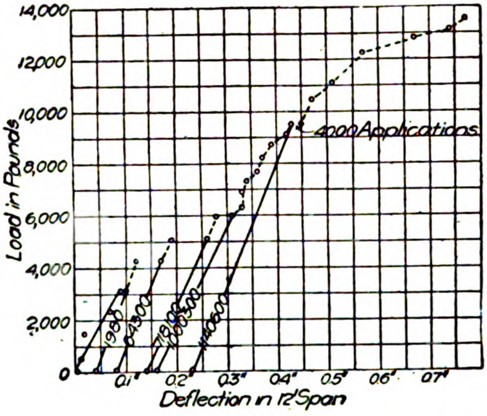


Fig. 8. Load Deflection Diagram for Beam No. 9.

Since the distance between the "Load On" and "Load Off" curves is very nearly constant for all the beams while the load remained the same, it is evident that the position of the neutral axis is not affected by repeated loading.

Five additional beams, making ten in all, were tested under repeated loading during 1909. These later series of beams had a smaller percentage of reinforcement so as to more nearly approach the critical ratio for a stress of 16,000 lb. per sq. in. in the steel and 500 lb. per sq. in. in the concrete.

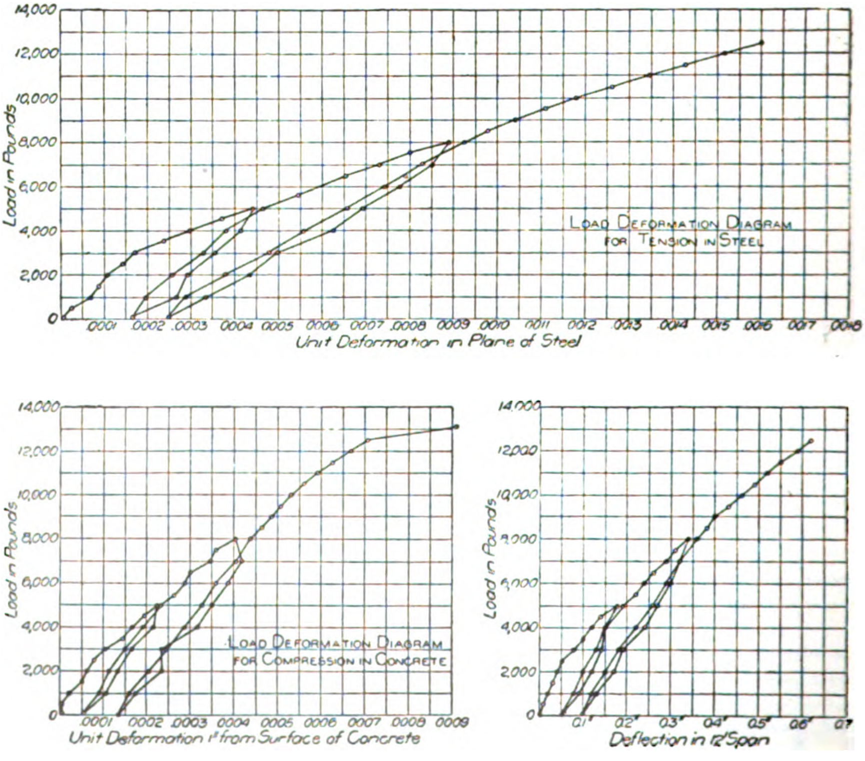


Fig. 9. Results of Test on Beam No. 10.

Below is a continuation of the tables numbered to correspond with the same tables in the foregoing:—

TABLE I.—TESTS OF STEEL IN BEAMS.

Bar.	Yield Point. Lbs. per sq. in.	Ultimate Strength. Lbs. per sq. in.	Elongation in 8 ins.	Reduction of Area.
Plain	35,600	52,000	30%	60%
Corrugated	53,400	88,800	13%	13%
Diamond	57,500	92,000	15%	19%

TABLE II.—TESTS OF SIX-INCH CUBES.

Concrete from Beam No.	No. of Cubes.	Age, Weeks.	Average Ultimate Strength. Lbs. per sq. in.	Extreme Variation.
11	4	15	3,200	25%
12	2	15	2,600	10%
14	3	12	3,300	30%
15	3	12	2,800	25%
16	3	8	2,500	10%
17	3	8	2,200	25%

TABLE III.—SUMMARY OF TESTS SHOWING MAXIMUM LOADS AND DEFLECTIONS.

Beam No.	Reinforcement.	Repetition Tests.				Ultimate Load.	Maximum Deflection.
		Total Load.	Unit-Stress. Lbs. per sq. in.		No. of Applications.		
			Steel	Concrete.			
		lbs.				lbs.	ins.
8	3 ½-in. sq. bars ...	4,170	15,800	640	1,490,000	10,600	0·5
11	3 ½-in. diam.	—	—	—	—	9,500	0·3
12	,, ,, ...	3,270	15,700	500	1,660,000	8,000	0·4
14	3 ½-in. sq. bars. ...	4,170	15,800	640	920,000	9,500	0·3
15	,, ,, ...	—	—	—	—	12,000	0·5
16	4 ⅝-in. Cor. Bars ...	3,270	16,500	500	960,000	9,000	0·5
17	,, ,, ...	—	—	—	—	10,800	0·6
18	3 ½-in. Diamond ...	3,270	20,000	640	1,200,000	(Not destroyed June 29th)	

Beam No. 8 was cracked on the compression side in removing from the apparatus, but on turning it over and setting in a test-machine it withstood a load of 10,600 lb. applied at the third points of a 12-ft. span.

TABLE IV.—RELATION OF REPEATED STRESS TO INCREASE IN SET.

Beam No.	Stress Repeated in the Concrete.	Increase in Set per 100,000 Applications.
8	640	0·0000138
12	500	070
14	640	242
16	500	145
18	640	176

These tests indicate:

1. That the ultimate strength of a reinforced concrete beam is not materially affected by one and three-quarter million repetitions of high working stresses.

2. That the maximum deflection is not affected.

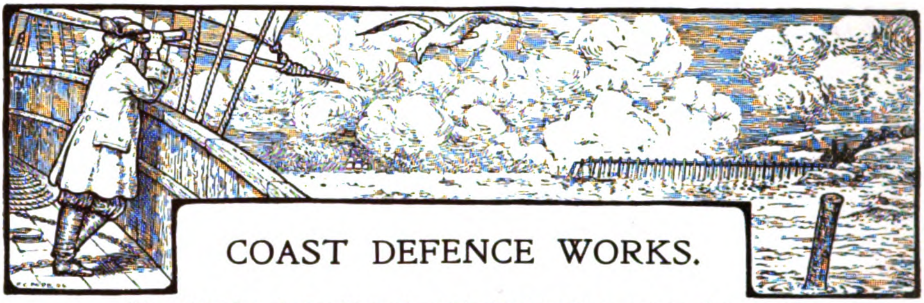
3. That hairline cracks become visible for such loads at intervals of 6 in. to 8 in., and grow deeper as the number of repetitions is increased, but that for one million repetitions no crack extended beyond the neutral axis.

4. That the bond between the steel and the concrete is not appreciably affected, as shown by the difficulty with which the steel was removed in breaking up the beams.

5. That the position of the neutral axis is not changed by repetitions of the load.

6. That the greater part of the set in the deformation in the plane of the steel occurs in the first few thousand applications of the load.

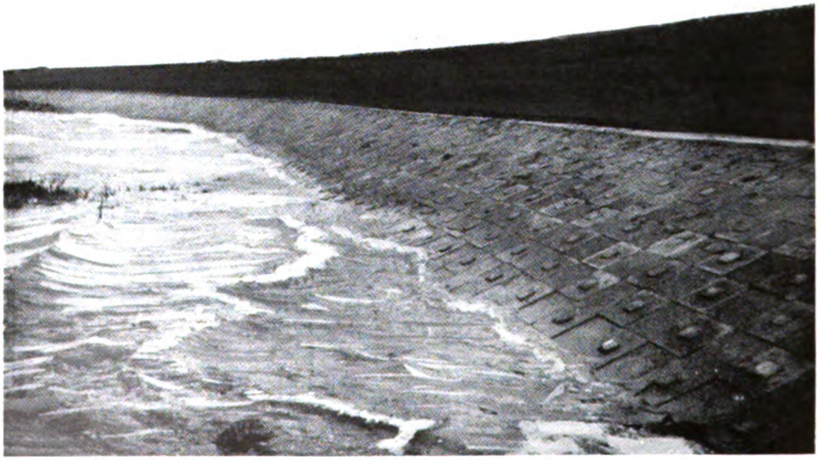
7. That the set in the deformation on the compressive side of the beam is also relatively large for the first few thousand repetitions, and that it increases with the stress applied and the number of repetitions.



COAST DEFENCE WORKS.

The subject here dealt with is of considerable importance, as many of our coast lines have suffered badly for lack of forethought in coast protection. Ireland in particular requires cheap foreshore protection works, and concrete lends itself well to the purpose.—ED.

ONE of the heaviest expenses attendant on the maintenance of the sea defence works of Holland, which depends on them for the continued existence of many of her low-lying and fertile marshes, has always been the facing of the seaward slopes with basalt rock pitching. This pitching, the stone for which is brought down from the Rhine Valley, complete with its necessary bedding, costs approximately £1 per sq. yd.



TYPICAL EXAMPLE OF TYPE "A" FACING IN HOLLAND.

Some few years ago Mr. Robert De Muralt, a Dutch State engineer, responsible for the defences of the Isle of Schouwen, in Zeeland, devoted considerable attention to the problem of reducing this cost, and the result has been the gradual adoption of special concrete defence works on the island and elsewhere on the Dutch coastline. The methods originally adopted by him were fully described in our issues of January, March and May, 1908. Since the publication of these articles, however, further improvements have been made in the defences of the Dutch dykes, and additional patents have been taken out in the chief countries of Europe and America.

Hitherto, the great difficulty of employing mass concrete work for coast defence has been the expansion and contraction due to changes of temperature, the bursting effects due to frost, and the uneven stresses which occur in rigid concrete structures, due to local settlement of foundations or subsidences of adjacent earth-work. The De Muralt systems are designed to reduce these destructive effects to a minimum, and are of two classes, adapted (1) for the protection of river and canal banks, parades or foreshores, not subjected to extremely heavy attacks by the sea ; and (2) for situations of extreme exposure.

The latter system we have already described in our previous articles, and we now wish particularly to refer to the former. The demand for this system of foreshore protection has been felt for many years. At the present time large sums are expended annually on the maintenance of river and sea walls whose outer slopes are protected in most cases in this country by chalk and rag-stone pitching. It is this particular class of defence work, so often found on the banks of sea estuaries, creeks and shelving foreshores, which the De Muralt light type of facing is designed to replace. When this facing is employed, the foreshore or bank is graded to an even slope, the maximum inclination of which is about ¾ to 1. If necessary, a clay face is formed on this, or, in particularly unstable materials, the bank is faced with straw or other fascine work. On the prepared slope, slabs known as " Type A " are laid ; these are about 2½ in. thick and 18 in. square. Every alternate slab has a taper hole in the centre, through which a long armoured key is driven, holding it firmly to the face of the bank. This slab, being provided with rebates on its underside at the edges, in turn holds down the slabs adjacent to it, so that the whole work when finished presents an even surface, having something the appearance of a large chess-board. Should any slight settlement of the bank occur, the facing accommodates itself to the new contours in the same

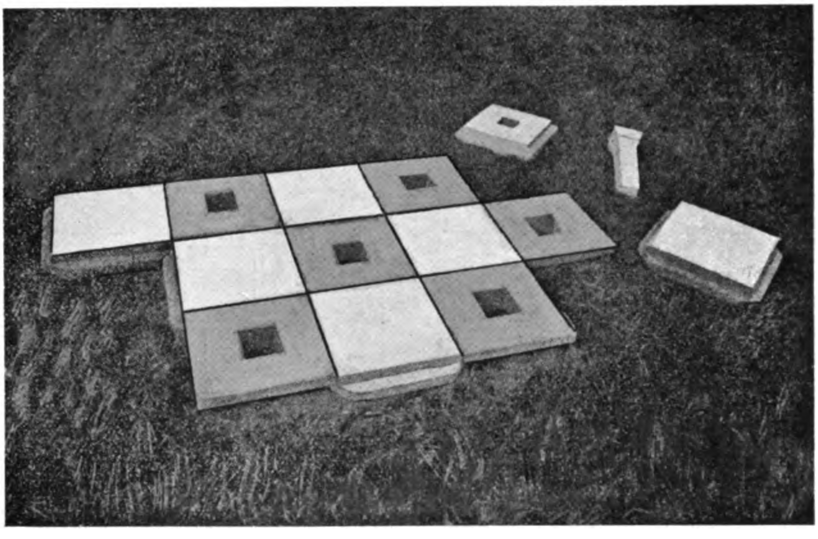


FIG. 1. CONCRETE SLABS AND KEY.

way as ordinary stone pitching. The cost of the work, however, is much less, running to an average of about 4s. 6d. per sq. yd., while its maintenance is a very small factor.

We hold that the system lends itself well for work on our shores, and we are thus glad to hear that a start has been made on work of this kind at Tilbury. A section of 138 sq. yds. of concrete facings has just been laid there on this system, on the bank near the terminal station of the London, Tilbury and Southend Railway. The facing consists of concrete slabs 2¾ in. thick and 16 in. square: every alternate slab rests on rabbets formed on the sides of the adjacent slabs. In the centre of every second slab is inserted an armoured "key" about 3 in. square and 13 in. long. These keys project into the ground from the underside of the slab some 10 in. or 11 in., thereby firmly securing the slab in position. The reinforcement in the slabs which receive the keys consists of a ring of ¼-in. steel bar, surrounding the hole through which the key passes. The key itself has also light steel reinforcement running through it. The slabs and keys are clearly illustrated in *Fig.* 1, and the diagram (*Fig.* 2) will further explain the system.

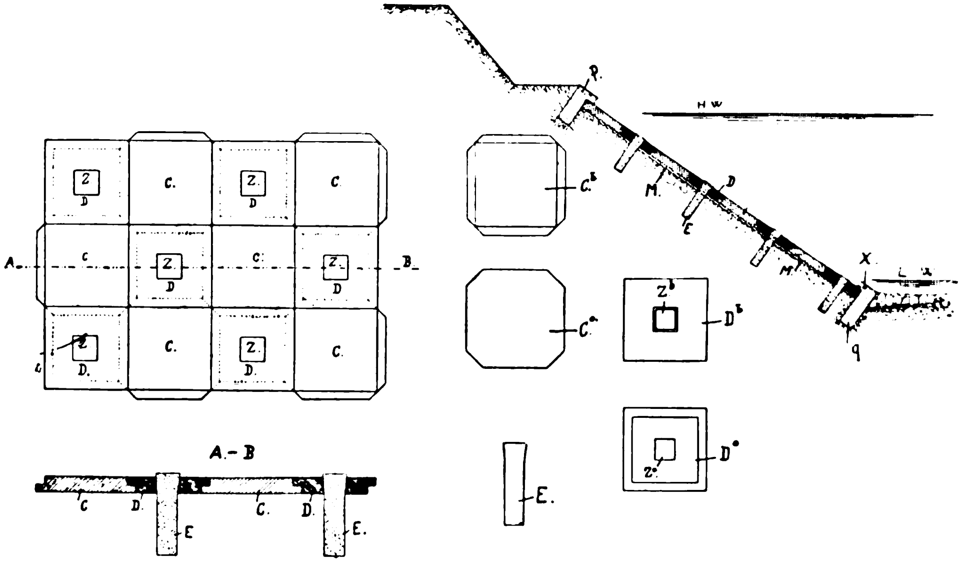


FIG. 2. CROSS SECTION AND PLAN OF TYPICAL FACING.

In the work under notice, which is illustrated in *Figs.* 3 and 4, the clay bank was made up and carefully graded to a slope of 1 in 2. A concrete foot wall, 18 in. deep and 9 in. wide, was first constructed on the saltings at the toe of the wall, and on the bank above this the slabs were laid. Pockets of clay were extracted with a kind of gouge of slightly lesser diameter than the key, and into the holes thus made the keys were inserted and driven home with a wooden mallet.

The great advantages claimed for the De Muralt facings over similar work in massed concrete are, first, that the whole facing is more or less elastic, and will settle with the earth behind it without causing cracks to commence on the surface; and, secondly, that the facing will also efficiently prevent the wash or scour from getting behind it and carrying away the material of which the river bank is composed. The cost of laying these slabs is given as 6d. per square yd., and two men lay 20 sq. yds. a day. In about a week the whole work, 100 ft. long by 12 ft. 6 in. deep was finished.

The work has been executed by Messrs. Cochrane & Sons, as contractors for Messrs. Foreshore Protections, Ltd., which is the name of the new British company which has been formed to work the De Muralt Patents, and whose offices are at 38 Victoria Street, S.W., under licence from whom all works on the De Muralt system in this country will be carried out. De Muralt slabs are now being manufactured by Messrs. Cochrane at their yard near Brimsdown, Essex.

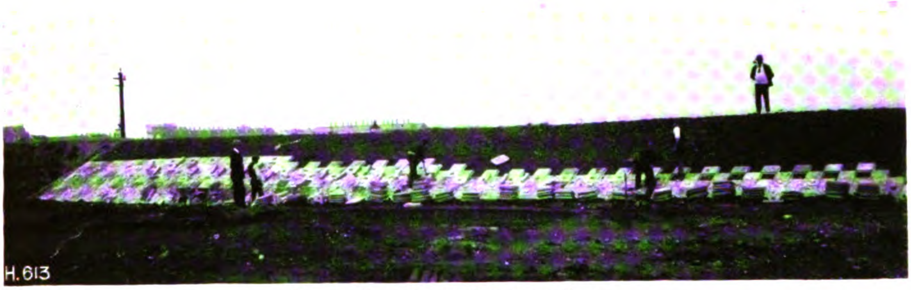


Fig. 3. Laying the Concrete Slabs.

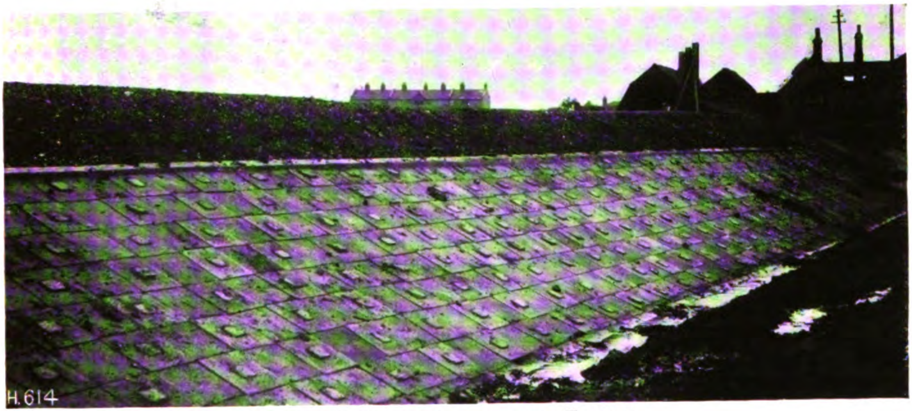
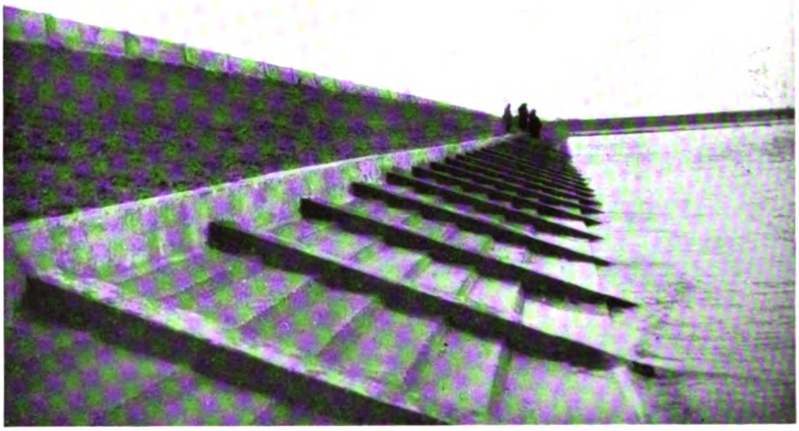
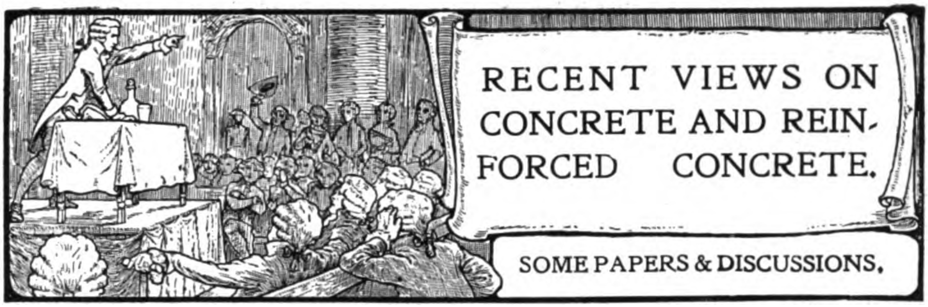


Fig. 4. Foreshore Protection at Tilbury.

The completed work at Tilbury has a handsome appearance, and its future maintenance will, it is alleged, be practically *nil*. The slabs used were imported from Holland, as their manufacture in this country had not yet been sufficiently large to place a stock at the disposal of the contractors when they started. As a fact, the slabs now being manufactured at Brimsdown will differ slightly from those used on the Continent inasmuch that they will be 18 in. square, four going exactly to the sq. yd. The armouring of the keys has also been improved upon, and now consists of two staples of ¼-in. steel bar, bound together with steel wire; this combination has been adopted to resist any bending stresses to which the keys may be subjected by the liability of the facing to slip down the surface of the bank, and at the same time to prevent the key from splitting when being driven home.



COAST PROTECTION, ISLE OF SCHOUWEN, ZEELAND.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

ROYAL INSTITUTE OF PUBLIC HEALTH.

REINFORCED CONCRETE.

Paper by ARTHUR C. AUDEN, A.M.Inst.C.E.

The Congress of the Royal Institute of Public Health was held at Birkenhead on the 19th July last, Sir Alexander Binnie (ex-President of the Institution of Civil Engineers) in the Chair, on which occasion Mr. Arthur C. Auden, A.M.Inst.C.E., read a very interesting Paper, entitled "Reinforced Concrete," of which we give a lengthy summary.

Early Examples of Reinforced Concrete.—The writer does not think that anyone describes reinforced concrete nowadays as a "new material." Its use may be new to them individually, but it is fairly widely known that it was used before the great majority of those now present were born—*i.e.*, before 1840—and this was followed by the manufacture and exhibition of a boat, made of wire mesh-work reinforcement embedded in cement, at the great Paris Exhibition of 1853, which boat—a punt—is stated to be still afloat; and the *Transactions of the Royal Institute of British Architects* for 1854 contain a very interesting paper on reinforcement of slabs, floors, etc., practically exactly on the lines adopted at the present day.

These instances, however, and many others which we have not time to quote, are of academic interest; but as we cannot go and see them they do not affect the important questions in which we are particularly interested—*i.e.*, those relating to the durability, upkeep, reliability, depreciation, etc., of reinforced concrete. We will, therefore, only consider a few instances which can be actually inspected and their condition ascertained.

Amongst others we may note the aqueduct for the Paris waterworks, constructed between 1855 and 1859, which is still standing practically just as it left the contractors' hands 52 years ago. In 1870 and 1871 Mr. Scott, of Walton-on-the-Naze, Essex, erected several reinforced concrete houses there, as well as some in Islington, London, most of which are now in existence, and can be readily seen by permission of their tenants, and a few years later (1877) a number of cottages were built at Croydon of reinforced concrete, some of which, the author is informed, have not yet been pulled down for street widening as the others have. The same remark, as regards inspection, applies to the use of concrete pipes for sewers, those, for instance, in Paris, now to be seen, having been put down about eighteen to twenty years ago, and there are some in Germany, laid in 1870, which are still in service.

Principles of Reinforced Concrete.—The writer is fully aware that many of the gentlemen present are quite familiar with the principles of reinforced concrete, but in case there may be others who are not so familiar, he hopes that he may be excused if he gives a rough sketch of such principles, particularly as they are really very simple.

We all know that concrete is like solid rock and will stand an enormous amount of compression—*i.e.*, it does not crush or split except under very heavy loads, and we know equally well that it is not nearly so strong in tension; *i.e.*, that we can pull it apart comparatively easily, being in both these characteristics very like cast iron; and also that both these conditions are always present when anything is being bent, or is loaded so that it would bend if it were not amply strong enough to support the load; and that as both these conditions—compression and tension—are present in the same piece of stick or beam, or whatever it may be, there must be a place where there is neither one nor the other—*i.e.*, where they are neutral, and in the diagrams the letter " N " means neutral and " N.A." " neutral axis " (which would be better if it were " neutral plane," as, even with a round piece, this neutral portion is a flat surface or plane, but neutral axis is the recognised name).

The writer then pointed out various details of construction in reinforced concrete, as shown by an excellent set of diagrams which he exhibited, tracing the analogy between a wooden beam " trussed " with steel bars and a reinforced concrete beam practically similarly trussed. He also drew attention to a diagram showing very distinctly the usual cracks or planes of cleavage developed in a beam or slab tested to destruction, and pointed out the importance of arranging that the shear-members reinforcing such a beam or slab be placed at an angle to the main tension rod, in order that they should cross such planes of cleavage at approximately right angles, thus most efficiently strengthening the structure against the occurrence of such cracks or planes of rupture until the full strength of the beam is developed.

The intending user of reinforced concrete is by no means helped by the immense number of systems and methods of reinforcement; somewhat the reverse, in fact, as every one is claimed by its inventors or promoters to be not only the best, but, in nearly every case, that it is equally good for every class of structure. This is certainly not so—even with the patents and systems which have survived and are in use at the present time and which have many excellent points, no single one has the monopoly of being the best in every instance and in every form of construction. A very important consideration in reinforcement is ease of handling during the actual progress of the work, and it is often advisable to sacrifice a little theoretical efficiency in order to ensure the use of systems not involving the handling of loose pieces—*i.e.*, shear members, etc.—which are easily misplaced by inexperienced workmen, and even if placed correctly at first are liable to be driven out of place during the consolidating or punning of the concrete. In this connection it may be mentioned that for flat surfaces—*i.e.*, floor slabs, walls, etc.—netting or woven meshwork is particularly adaptable, as all wires are maintained at their proper pitch and cannot be displaced during handling and punning, and, also, the cost of handling is reduced to a minimum. A great advantage is also secured by the fact that in long slabs, etc., of comparatively narrow span the cross-span wires take the load, the longitudinals being merely light, cheap wires holding the cross-wires in pitch.

It is also important that all reinforcement should have sufficient rigidity to prevent its bending by its own weight when placed in the moulds. This is especially noticeable in the case of long spans, where it is by no means rare to find reinforcement placed in the compression area of the concrete " sagging " down to even perhaps below the neutral axis, whereby the aim of the designer is entirely defeated by its non-rigidity. In the case of columns and struts a rigid reinforcement is particularly desirable to prevent the rods, etc., bulging outwards, and thus approaching too near to the outer edge of the concrete, and thereby endangering the fireproof qualities of the structure.

With reference to the important question of shear, practically all the cracks occur at an angle of about 45 deg. to the neutral axis, and for this reason it is now generally accepted that all members or stirrups to resist such shear should be inclined at an angle of about 45 deg. to the main tension bar, and should also be rigidly attached thereto. By this means they pass through the planes of rupture at right angles, which reinforces them in the most efficient manner possible. An effective reinforcement against shear may also be obtained by bending up the tension rods at intervals to the desired inclination, but owing to the large number of rods required this method is often not so economical as fixing the shear members upon the rods themselves.

The reinforcement of columns or struts consists of vertical rods, and to prevent them from spreading or bulging, wire spiralling is wound round them, or hoops or rings are placed around them spaced according to the load and dimensions of the column.

Spiralling gives very good results, but care should be taken that the spirals should all clasp the verticals equally, as otherwise there is a danger of failure owing to unequal stress. This can be obviated by first making the spiralling on a cylinder and then slipping it over the verticals. In long columns the spiralling should not be worked in too long lengths, as should the concrete have to be dropped from any considerable height the mixture of the concrete at the foot becomes very uncertain, but care should be taken that each length of spiralling is interlaced with the one previously in position to avoid weakness at such jointings.

The question of unequal stresses is not so apparent with hoops or rings, as these can be made exact replicas of each other, thereby ensuring an equal strain on each one. High-carbon steel may be advantageously used for such hoops, as it is stiffer to resist distortion under stress. It is important to design the reinforcement in straight lines, as if the steel is not straight between its points of resistance the full strength of the hoop cannot be developed. The joints of all verticals in columns, etc., should be formed by close-fitting sleeves, as this form of connection not only keeps the rods true in alignment but prevents any weakness at such joints.

In beams or floors running continuously over several columns care should be taken that all such are reinforced above their neutral axis where they pass over the supports, as in these cases the upper portion of the beam or floor becomes in tension and the lower portion in compression, *i.e.*, a complete reversion of a freely supported beam or floor. As this plane of " reverse flexure " has not up to the present been exactly located, the reinforcement over the supports should overlap that in the lower portion of the beam, or the same result may be obtained, especially in floor slabs, by bending up the reinforcement meshwork over the supports, *i.e.*, beams, cross-walls, etc., and then downwards again to their original position in the bottom of the next slab of flooring, etc. Reverse flexure rods are also needed in the ends of beams or floors built into walls, the rods being continued and bent into the walls, to form a safe anchorage, or in the case of resting only upon the wall or upon a projection therefrom the ends of the beams or floors must be designed with " reverse flexure " reinforcement placed near their upper surface.

These " reverse flexure " rods are in no way connected with compression rods, which are sometimes necessary in the case of long beams or girders to strengthen the portion of concrete in compression above the neutral axis or plane, but where the depth of the beam can be conveniently increased it is more economical to do so, thereby increasing the area of concrete in compression and doing away with these rods. But, of course, in the case of bridges, heavy floors, etc., it is often imperative to keep the depth of the beam as small as possible, when compression members are therefore necessary, but it is important to note that such must be carefully tied or hooped so as to prevent bulging exactly as if they were in a column or stanchion.

In the case of beams supporting floors, a portion of the floor slab, about five times the breadth of the beam, may be considered as available for bearing the compressive stresses, and the fact of the floor and beam being all in one piece also tends to the strength of the structure.

In reinforced concrete exposed to the weather, temperature stresses are also to be guarded against. In bridges, etc., these can be arranged for by hinges or ordinary expansion joints, but in general work it is always a good practice to provide against such by increasing the reinforcement and the scantlings of the structure, etc., which, although not theoretically correct, answers very well in practice.

Materials.—There is really only one thing to remark about good granite chippings, and that is the presence of fine blunt dust, due to the process of breaking, which is apt to prevent the proper adherence of the cement, and it is generally advisable to accept only such stone from quarries where blowers or exhaust fans are fitted to the crushers, even at a slightly higher price, than from quarries not so fitted.

With reference to second class or " artificial " aggregates, clinkers and ashes from destructors, steam boilers, etc., make a very good concrete, and a very large tonnage is so made, but care must be taken that they are quite hard and free from dust, fine soft ash, or pieces of partly-burnt coal, and, with ashes, those free from the same and in addition only those of uniform colour and texture and which will float in water should be used.

Blast furnace slag, when hard and tough, also makes a very good aggregate, as does also that from cupolas, but care should be taken in both cases to use only such containing a very limited amount of sulphur, which is apt to attack the reinforcing steel, with disastrous results.

Coke breeze, although suffering from the same drawback as regards sulphur, has been found to make a concrete which, although not quite so strong in its resistance to tensile and compressive stresses, owing to its soft nature, still gives very good results when allowance is made in design for such difference in strength. It is the opinion of many that coke breeze does not make a really fireproof concrete, but this opinion is not quite consistent with the tests recently carried out by the British Fire Prevention Committee, in which the results of the slab made with this material compared very favourably with those of other, and often more costly, aggregates.

In many parts of the country, particularly in the Eastern counties, flint is the only local stone obtainable, and this, with the exception of its tendency to split and "fly" when heated, makes a really good concrete, very hard and tough. If, however, the flint is passed through a crusher, the tendency to "fly" is much reduced, as the stones break in the crusher along their planes of crystallisation, leaving the flint in the homogeneous pieces which are bounded by such planes.

Broken bricks are not a very good aggregate for reinforced concrete, but may be used if of close texture and thoroughly cleaned from adhering pieces of old mortar, dirt, etc., but, of course, as is well known, they give excellent results in mass concrete. Burnt clay and gault may also be used if hard and well burnt, but should be tested by being left in water for two or three days, when, if soft or "crumbly," they should be rejected.

Free lime, if present in aggregates, is very detrimental to the quality of the concrete, but there are two forms of this material, *i.e.*, free lime, which is very dangerous, and carbonate of lime, which is practically harmless. Washing and exposure to the sun will be found to change the dangerous free lime to the practically safe carbonate.

As it is very often necessary that aggregates have to be washed and screened, it may be mentioned here that "jigging" is a much better method than ordinary screening, *i.e.*, throwing the material against an inclined sieve or screen, as not only may the jigging and washing be done in one process, but also better shaped pieces are obtainable—particularly with artificial aggregates—as this method knocks off all weak corners and adhering pieces of soft material, etc.

Sand. — Some authorities hold that quite a considerable percentage of loam or clay does not affect the strength of the concrete, while others state that it must be as clean for concrete as if it was to be used in a filter bed. Personally, the author is of the opinion that the most economical practice lies between these two extremes, as certainly it has been proved that a little, say 5 or 7½ per cent. of loam, does not affect the strength of the concrete.

The use of very fine "wind-driven" or "fluffy" sand is not advocated, as it is of a very dusty nature, and it is also very soft; in fact, it may be said that when two sands, varying only as to the size of grains, are offered at the same price the coarser one should have the preference.

Cement.—With the high standard of cement now prevailing little can be said *re* this material, it being sufficient to remark that all such complying with the British Standard Specification can be used with perfect confidence, but a word of warning should be added against the use of cheap foreign "cements," which are not worthy of the name, the employment of which, it is encouraging to note, is very much diminishing in this country.

Centering.—With regard to centering or false-work, the erection of this should always be carefully supervised, as upon its efficiency depends the success of the work. All timbering should be strong and well stayed to prevent its sagging when the concrete is placed and rammed into position, and all joints should be close and tight, to prevent leakage of the cement before setting. Care should be taken to remove all shavings, saw-dust, pieces of wood, etc., from the moulds before the concrete is placed in position.

Should a good surface be required on the concrete this can be obtained by painting the centering with oil or whitewash, or by lining the moulds with oiled paper, but should the work be required to be rendered a rough surface is, of course, desirable.

The removal of the centering also requires very careful supervision, and as the length of time it should be left in position is affected so much by the circumstances peculiar to any particular case, it is absolutely necessary that the same should only be taken down with the consent of those in charge who have had experience in this class of work. Frost particularly retards the removal of the centering, and lack of experience in these matters has often been attended by disastrous results to the structure. In no mode of construction has supervision to be exercised so much as in reinforced concrete, as what, to those unversed in its theory as well as practice, may seem a trifling disagreement with the plans, especially in the placing of the reinforcement, may easily endanger the stability of the structure; it is therefore important that only those with considerable experience should be entrusted with the supervision of work in this material.

When speaking of centering, it is interesting to mention the increasing use of slabs of reinforced concrete for walls, floors, roofing, etc., which are first moulded and matured, either on the job, or—preferably—at some suitable workshop, and erected between or on the columns or beams as required. This method has the great advantage of almost entirely eliminating the use and cost of centering and is particularly applicable to industrial dwellings, cottages, bungalows, and similar buildings, where there are several built to the same, or but very slightly differing, designs.

Concrete for Sewers.—With reference to the uses of reinforced concrete, these are really almost innumerable, but when speaking before gentlemen interested in matters affecting Public Health, the question of such for sewers, septic tanks, bacteria beds, and so on, is of great importance, and certainly the evidence is strongly in favour of a continuation of its use for such purposes. A list is given below of some of the sewers, etc., which have been in use a sufficient time to justify their being quoted as satisfactory, and there is no doubt but that the large number laid more recently will, in their turn, provide ample evidence of an equally satisfactory nature.

When mentioning sewers and the action of sewage and its gases on concrete, a few investigations made by the Author may prove of interest. Some little time ago a sewer-pipe was found to have deteriorated, *i.e.*, the concrete had become " short," or " gone crumbie," as the men expressed it, and, as this was exceedingly rare, it created much interest. Some authorities on the subject said it was due to too little air, and that if the pipe had been better ventilated it would not have occurred, as the gases would not have had time to attack the concrete; another said that it was due to too much free air, while a third was of opinion that it was due to some strong trade effluent!

Taking the above in the order given, the Author first investigated the action of sewage and gases closed in from air, and, among others, a good instance is a liquifying tank built to the designs of Mr. R. T. Surtees at Hexham, where the gases are entirely enclosed; in fact, a pipe being put through the cover gases issue therefrom under quite a little pressure and burn when lighted almost like an ordinary gas jet. But a very careful examination of the interior of the tank, which was built in 1897, shows that the concrete is as sound and perfect as on the day it was put in, and this even at the water level, which, of course, varies from time to time, and which is where the greatest action, if any, would take place.

Then, as regards sewage with a plentiful supply of air. There are, of course, many miles of sewers already laid and in service to which reference has already been made, but in order to ascertain the effect on ordinary thin cement rendering, the Author carefully examined an old-fashioned " privy," which also served as a receptacle for house refuse, *i.e.*, decayed vegetables, bones, ashes, old tins, etc., which was being carefully cleaned after a good many years' use with a view to the installation of more up-to-date arrangements, but notwithstanding the fact that the contents were exceedingly strong, there was no sign of deterioration anywhere, in fact, other than a black stain extending at the deepest to slightly less than $\frac{1}{16}$ in. into the concrete, there was nothing to show what the contents had been.

With reference to the question of deleterious trade effluent, this was more difficult, as no one will ever acknowledge that his sewage is anything but perfectly harmless. However, through the courtesy of the Chief Surveyor of the Calico Printers' Association, the Author was able to send a 16-ft. length of 2-ft. diameter sewer pipe, manufactured by Messrs. Siegwart, Limited, of London—these pipes being made by machinery, there is perfect certainty that the reinforcement is in its correct position—for tests at one of their works, which were carried out over a period of several months, not only with liquid of the ordinary strength of their effluent, but also with special solutions representing four or five times this, and the reports are perfectly satisfactory in every way. Of course, many other methods of testing the action of sewage on cement will occur to many of the gentlemen present, but the three above mentioned may be of interest also.

REINFORCED CONCRETE SEWERS.

Place.	Date.	Length.	Diameter.	Remarks.
Paris	1892, 18 years ago	Several miles	—	Coignet system, in excellent condition
Septic tanks, Grays Urban District Council	1894, 16 years ago	—	—	In use and quite good
St. Joseph, U.S.A. ...	1902, 8 years ago	—	8′	Extensions to existing brick sewers
Boston, U.S.A.... ...	1902, 8 years ago	—	—	Owing to being unable to secure sufficient room for filling, which is necessary to keep brick from bursting, R.C. was accepted
St. Paul's, U.S.A. ...	1902, 8 years ago	157′	13′ 6″ span	Examined 7 years after completion and found perfectly sound
Concrete sewers ...	1902, 8 years ago	Several miles	42″ to 24″ interior diam.	Under the care of the City Engineer, Mr. Arthur Collins
Glasgow (North Side) sewage system	1904, 6 years ago	Considerable extensions	—	Mr. David Home Norton, M.I.C.E.
Sewers at Lancaster, Pa., U.S.A.	1904, 6 years ago	—	4′ 9″ radius	Expanded metal
Leeds Corporation sewers	1905, 5 years ago	Big extensions	Invert. rad. 3′	Very soft nature of ground
Cleveland, U.S.A. ...	1906, 4 years ago	Many miles	Up to 12′ diam.	Mainly on Bonna system
Walmington, U.S.A. ...	1909, 1 year ago	7,500′	4′ to 9′ 3″	—
Waterbury, U.S.A. ...	Recently completed	3 miles	4′ 6″ × 4′ 5″	Expanded metal and trussed bars
Drainage canal, New Orleans, U.S.A.	—	Considerable lengths	6′ 3″ × 2′	In carrying out this work R.C. was also extensively used in roofing the canal
Laguna Street, San Francisco, outfall sewers	—	Several miles	6′ internal	Invert of vitrified bricks
Mariposa Street, outfall sewer	—	—	6′ internal	

NOTE.—On looking through the reports of Professor Max Grey, of Royal Testing Station for Building Materials, Gross Lichterfelde, Berlin, it is found that there are several German towns where concrete sewer pipes have been in existence for the last 40 years, and practically all the records that have been kept show that the cases of destructive action of sewage upon Portland cement concrete pipes have been very few indeed.

Buildings in General.—In general building work reinforced concrete can be used with great economy in the construction of the foundations, skeleton framework, floors, roof, etc., the fact of each floor carrying only its own area of the walls considerably reducing the thickness of the panels between the columns, etc.; especially in the lower floors, which would otherwise have to be of considerable thickness, in order to support the whole weight of the wall itself. In addition to many other advantages for reinforced concrete may be mentioned the speed with which it can be erected, this being a very important consideration in factories and other commercial buildings.

Dock and Retaining Walls.—The great advantage in the use of reinforced concrete for these is the great saving in space and excavation over masonry or mass-concrete, and now that it is generally accepted that no deterioration takes place in the embedded steel, its use for such purposes will no doubt largely increase.

Chimneys.—In large factory stacks a considerable saving in first cost is effected by the use of reinforced concrete, and this, in addition to the elimination of the cost of upkeep, *i.e.*, in the case of brickwork, pointing, etc., appears certainly to indicate a continuation of its use for such structures.

Piles, Piers, and Jetties.—Their great strength over wood, etc., and the absence of deterioration are the principal recommendations of the use of reinforced concrete in connection with these.

Railway Sleepers.—Although reinforced concrete sleepers are slightly more costly in initial price than those made of wood, it seems probable that their great lasting qualities will make them really more economical in the end, and large repeat orders recently given out seem to indicate the satisfaction derived from their use.

Telegraph and Tramway Poles.—Large numbers of poles in this material are now in actual service; their being slightly cheaper than such in steel and entirely free from any upkeep, painting, etc., has induced many to give them a trial, with eminently satisfactory results. These poles being tubular, *i.e.*, the same as pipes, great care is necessary that the reinforcement should be placed very accurately in the exactly correct position, and the author would add that in this connection he has known cases where, on the poles or pipes being "cut open," it has been found that the reinforcement is all astray. This is especially liable in pipes moulded between two shells, where it is almost impossible when ramming the concrete—which is so necessary to make the pipes water-tight—not to knock the reinforcement out of position.

Engine and Dynamo Beds.—The use of a reinforced concrete slab for machinery foundations is found to eliminate all vibration, which in the case of hotels, etc., supplying their own power is particularly objectionable.

Boats, Pontoons, etc.—These have been built with considerable success for many years now, several having made voyages of quite a considerable length. The cost is greater than with wood, but less so than for steel, particularly when more than one is made from the same mould.

Pit-head Gear and Pit Props.—The fact of these being fireproof is of distinct advantage, the latter, though slightly heavier, being much stronger than wood, and, of course, the question of depreciation is of special importance, as reinforced concrete props are not in any way affected by water. The same remarks also apply to fence posts.

Sea Defence Works.—It will be generally agreed that Holland stands first in every question of sea defence, and the use of reinforced concrete in that country is so well established and is increasing so rapidly that there can be no question as to its being the best material for the purpose.

Dairies, Cowsheds, etc.—Farm buildings built in this material are always perfectly sanitary, and can always be kept so, as they can be easily cleansed by "swilling out" with a hose. In a well-designed reinforced concrete dairy, shippon, etc., it is really wonderful how this material can be utilised, entirely doing away with the use of wood, even for the smaller internal fittings, etc.

Foundation Rafts.—Of course, the use of mass-concrete in foundations is well known, but in soft, boggy or "shifty" ground it cannot compare in efficiency with reinforced concrete, which is light, strong in tension, and perfectly monolithic over the whole sight. The Author has recently designed a foundation raft for Mr. J Francis Doyle, a leading architect of Liverpool, for a church on very soft seashore sand, which thus enables the use of land, which otherwise would have been impracticable for building purposes.

Coal Bunkers.—Reinforced concrete is greatly superseding the use of steel for these and similar structures, chiefly on account of its cheapness and the absence of cost of annual scraping and painting.

Tanks, Swimming Baths, etc.—The large number of tanks, etc., now in use testify to their efficiency in the storage of water, brine, oils, etc., and if the concrete is well mixed and rammed they are found to be perfectly water-tight, especially if rendered on their inner faces with, say, 1 in. thick of one and one cement and sand.

Grand Stands, etc.—The rapidity with which these can be erected is often of great advantage, and, of course, all cost of upkeep, which in these structures is so very considerable, is eliminated.

Magazines for Explosives.—Owing to its splendid fireproof qualities, reinforced concrete is particularly suitable for these structures, and recent tests have proved that even in the case of explosion there is no danger of large pieces hurtling through the air, as it was found that the reinforcement was not scattered, but only rent, while the concrete was blown away in the form of coarse dust.

Generally.— Of course, the use of reinforced concrete has met with opposition. No method or material worth anything ever did otherwise, and it is fortunate for us at the present day that this has been the case, as this strenuous opposition has resulted in the introduction of vastly improved methods and appliances, all of which tend to better and cheaper work.

This question of opposition brings us in natural sequence to that of failures and accidents due to the employment of reinforced concrete, and really it is impossible not to admire the skill and care with which such have been "worked up" by interested parties, but although we all like to see, if I may so express it, "a good fight put up by those who know they are playing a losing game," the writer fears that many of the methods employed cannot be approved of under any circumstances. One of the most marked features of this matter is the extreme prominence given to any little accident where reinforced concrete is being used (which are inevitable seeing the enormous amount of work in progress in this material), and the comparative silence about serious failures in other forms of construction, but if any gentleman present has time to look into the matter he will find that the value of work completed and in course of erection in reinforced concrete amounts to many millions sterling, and that the loss from accidents does not equal as many hundreds.

It is a source of considerable gratification to those interested in reinforced concrete work to note that in so very many cases the municipal and local by-laws have been so amended as to permit the use of this material, and in the majority of cases this is done in a particularly satisfactory manner, *i.e.*, that of judging each proposition on its own merits, it being a rule that detailed drawings and calculations are submitted, which are carefully checked, and, if proved satisfactory, permission to proceed is given without further reference to the by-laws other than such relating to the height of the building, line of frontage, etc.

The position, however, of the Local Government Board in England on the matter of loans for work in reinforced concrete is still somewhat freely criticised, but time and patience will see this matter remedied. In Ireland, however, a much more up-to-date procedure is in vogue, and which is fair and satisfactory to all concerned.

There is, however, another matter in connection particularly with the design of reinforced concrete work, which is unfortunately not by any means so satisfactory, and that is the very common practice of making the contractor also the architect, designer, and quantity surveyor. This practice has a most serious tendency, and constitutes a serious temptation, particularly to men in a small way of business, to "cut" their dimensions and strength; in fact, it has been said that "it is the man who will take the biggest risk who puts in the lowest tender and gets the job."

It is strongly advocated that all work in reinforced concrete should be, as is the case in brick and stone, carefully and fully designed, and a proper bill of quantities made out for it, so that every contractor can tender for the work exactly on the same basis, and though he may "cut" the price if he so desires, he cannot endanger the stability of the structure nor the good name of reinforced concrete by reducing the dimensions and consequent strengths of his material.

DISCUSSION.

The Chairman, Sir Alexander Binnie, Ex-President, Inst.C.E., said that all present would agree that they had had the pleasure of listening to a very interesting paper on reinforced concrete, a subject which is occupying a good deal of attention at the present time owing to its great utility in numerous branches of engineering, and he was glad to see that the Members of Royal Institute of Public Health were also giving attention to the study of this very useful material, and Mr. Auden's paper had conclusively shown that the use of this material in raising the standard of modern hygiene had passed the experimental stage. The interest in the paper was considerably increased by the fact that it was evident that the author had had considerable experience in his subject.

He had much pleasure in asking Mr. Travers to propose the vote of thanks, which he was sure would be cordially supported by all the members present.

Mr. W. H. Travers (Wallasey).—He had much pleasure in proposing a vote of thanks to the author, as those of them who knew Mr. Auden recognised him as an authority in the subject upon which he had presented so excellent and instructive a paper.

It would be agreed that the primary essentials of all good building were conscientiousness in design and integrity, conscientiousness in design and execution, and integrity of material. This was especially the case with reinforced concrete, and the author's reference to the risk of shavings and other foreign matter becoming accidentally or carelessly incorporated in a structure showed that he was alive to the fact that the human element played a relatively larger part and formed a more serious and important factor than in ordinary building operations. The fear of internal disruption from oxidation of embedded metal was now generally agreed to be a mistake; always provided the surrounding concrete to be sound. As a matter of fact the preservative effect upon the metal was agreed, and it was also conceded that in certain directions sounder and more economical work could be done in reinforced concrete than by ordinary methods. Nevertheless, the results of bad design mistakes or carelessness, were likely to be fraught with serious results and, no doubt, this was a case where some authorities felt that to " hasten slowly " was justified.

Referring to a paper recently read with reference to the disintegration of certain sewage works in concrete at Hampton, which was pretty generally attributed to the action of specially strong sewage and the presence of sulphuretted hydrogen, he would be glad to know whether the author could cite any cases of disintegration within his own experience, and the cause.

Mr. P. C. Cowan, D.Sc., M.Inst.C.E., Chief Engineer, Local Government Board for Ireland, also supported the vote of thanks to the author. No doubt the use of dirty sand gave fairly good results, but he personally thought that clean sand was more reliable. With reference to the placing of the concrete, he was of the opinion that the concrete should be fairly sloppy, but did not advocate its being too wet. He thought that the use of reinforced concrete had a good effect on the workmen employed in its construction, as it was a material requiring a considerable amount of individual responsibility; he regretted, however, that good foremen were very scarce, as in a recent job at Belfast it was necessary to send for a Danish foreman, as apparently a suitable man could not be obtained otherwise.

With reference to the attitude of the Local Government Board as regards the repayment of loans for structures in reinforced concrete, Mr. Cowan remarked that in Ireland his department had now decided to place reinforced concrete on exactly the same basis as ordinary building materials, and that 50 years had been granted for the repayment of the loan for the erection of a bridge in this material in Ireland.

With reference to the action of sewage on reinforced concrete, this he did not think had been proved to be in any way serious, but, of course, very much depended on the conscientious workmanship and good materials employed in the work.

Mr. R. P. Hirst (Southport).—He had not had much experience in reinforced concrete as now understood, but had used it to a limited extent with good results.

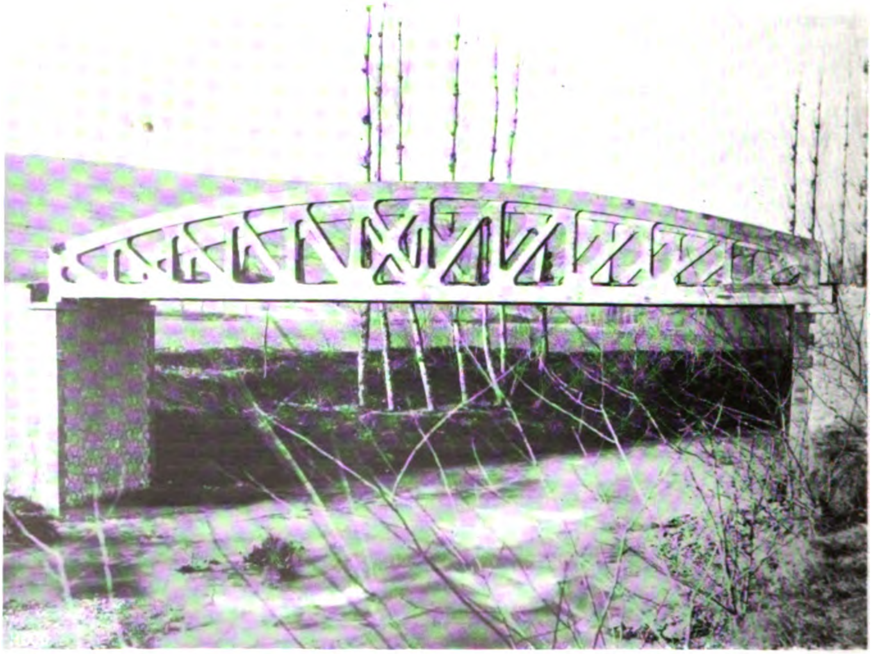
He had, however, used largely combinations of concrete and steel with excellent results, but not in the form now understood as reinforced concrete. He was opposed to the facing or plastering of concrete, but he had found no deleterious action of sewage on concrete, but feared more the action of salt water.

Mr. R. T. Surtees, M.Inst.M.E.—There seems to be some little doubt at the present time as to whether concrete will resist the action of sewage, but he thought they need have no fear if ordinary precautions are used in its adoption. The liquefying tank, referred to in the paper, is a capital illustration, for it has been in constant use for the last thirteen years, and when he saw it two months ago it was undoubtedly in better condition than when first put in use. The sewage it deals with is of a very vile description, most of it being highly charged with effluents from tanyards, chemical manure works and such like. The concrete with which it is built is composed of an aggregate of clean river gravel and sand, carefully gauged and mixed, and well rammed to secure the greatest density. This ramming of the concrete is most important in securing success with reinforced concrete. If you make your concrete so dense as to be impervious to moisture and air, there will be no depreciation of either steel or concrete, provided the materials of which it is made are of such a nature as to secure this density.

In taking down some of the brickwork of Blackfriars Bridge, it was found to have been built with hoop-iron bonds laid in cement mortar, and in places this hoop-iron was very much corroded, more so above low water level than below it. Very careful examination was made of the mortar, the brick, and also the steel, samples of each being submitted to a searching analysis. The conclusion come to was that the action was due to the sulphur in the London atmosphere penetrating through the mortar and so reaching the steel. It was his privilege to be interested in another job, about a couple of hundred yards below this bridge, where hoop-iron bond was also found in the foundations, and the piece he had here is part of it. As they would see, it is in excellent preservation although the building is said to have been erected at least 300 years ago.

He had carried out a large number of tests with different aggregates and various mixtures of cement, and one set of blocks was particularly interesting. They were composed of a concrete made with Portland cement and blast furnace slag, the latter containing as much as 2.3 per cent. of sulphur. Pieces of steel were embedded in these blocks, the ends of which were allowed to project a few inches. They were then put into and out of water for a period extending over several years, until the projecting steel was highly corroded. They were then boiled in an acid solution, and, although the exposed steel was practically eaten away, no deleterious action could be noticed on the covered steel.

Mr. Auden referred to a boat made some years ago of this material, and he understood that, after careful experiment, the Italian Government had ordered several boats to be made for use in their dockyards. He wondered if Mr. Auden had evidence to lead them to hope that in the near future our ocean liners and battleships would be built of reinforced concrete!



Bow-string Bridge at Sabarat (Ariege).
(*See page* 691.)

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course or construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

RECONSTRUCTION OF HAYDON BRIDGE OVER THE TYNE.

The majority of old river bridges have what may be termed a " hump " in the middle and are always more or less dangerous for the passage of fast motor traffic such as we get on our main roads nowadays. The approaches to them are usually steep and difficult for horses to negotiate with ease, besides which there is always the danger of the steep descent on the other side. To obviate this danger at Haydon Bridge, it was decided to reconstruct two of the arches of the bridge over the South Tyne in reinforced concrete. The illustration on this page shows the finished structure which is now open to traffic.

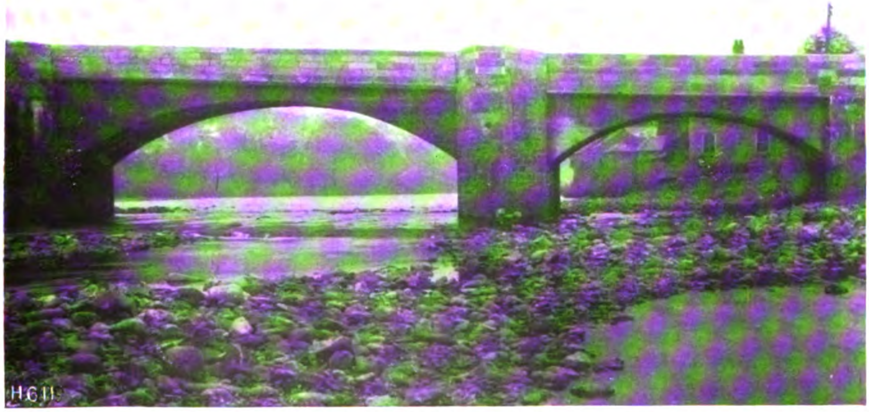
The roadway is carried on a decking of reinforced concrete 8 in. thick, supported by three solid spandrils or ribs springing from the old piers and abutment. From the drawing of the section it will be seen that the parapets and footpath are supported by a continuation of the road decking in the form of cantilevers.

The sectional elevation shows the form and disposition of the reinforcement in the ribs. The top and bottom arch bars were connected by hoops, which, in turn, were suspended by vertical bars from the reinforcement in the road decking. The arrangement of the reinforcement in the road slabs can be seen from the illustration.

The official test by the North County Surveyor, Mr. J. A. Bean, took place on the 13th of June last, the following results being obtained :—

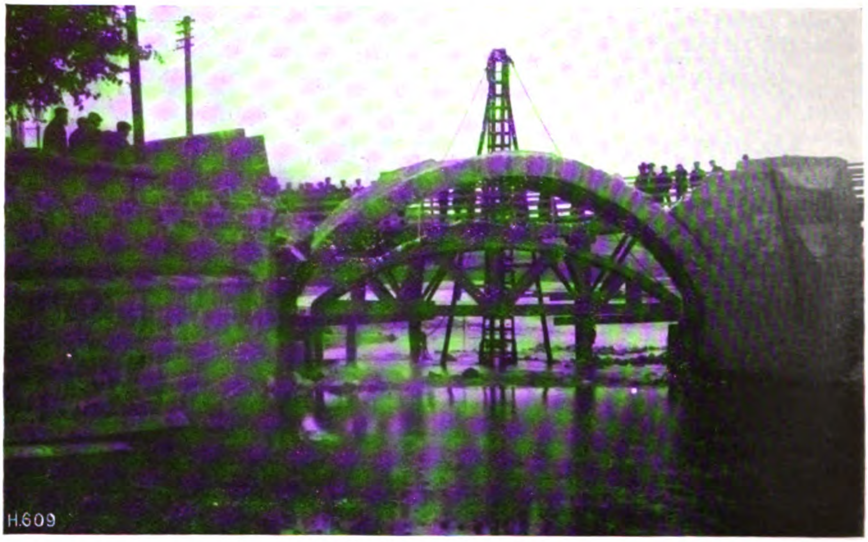
Large Arch.—Span, 60 ft. 6 in.; load, two 17-ton steam rollers; deflection, 0·04-in. on centre spandril, 0·03-in. on outside spandrils, equal to $\frac{1}{18150}$th of the span on the centre rib.

Small Arch.—36 ft. 6 in. span; deflection, 0·016-in. on each rib, equal to $\frac{1}{27375}$th of the span.

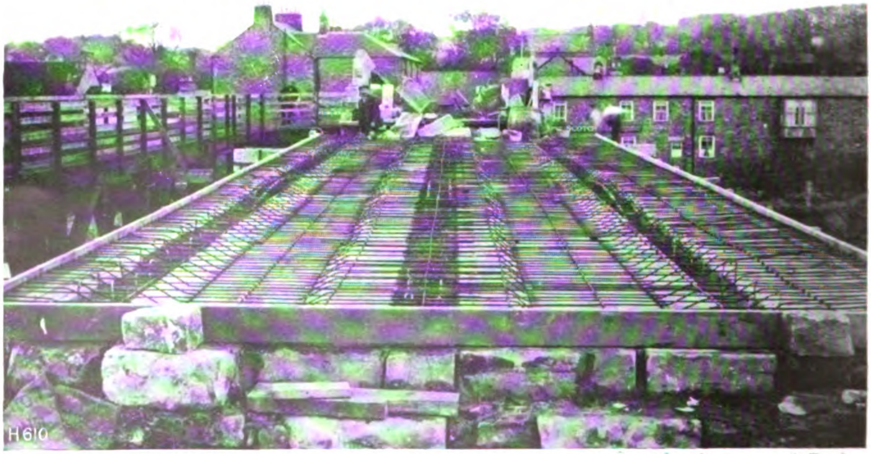


View of the new arches.
Reconstruction of Haydon Bridge.

The engineers for the work were The British Concrete-Steel Company, Cathedral Buildings, Newcastle-upon-Tyne, and the contractors were Messrs. Firth & Co., Derby. The reinforcement for the whole of the works consisted of indented steel bars.



Demolition of 36 ft. 6 in. stone arch.



Reinforcement of road decking for 36 ft. 6 in. arch.

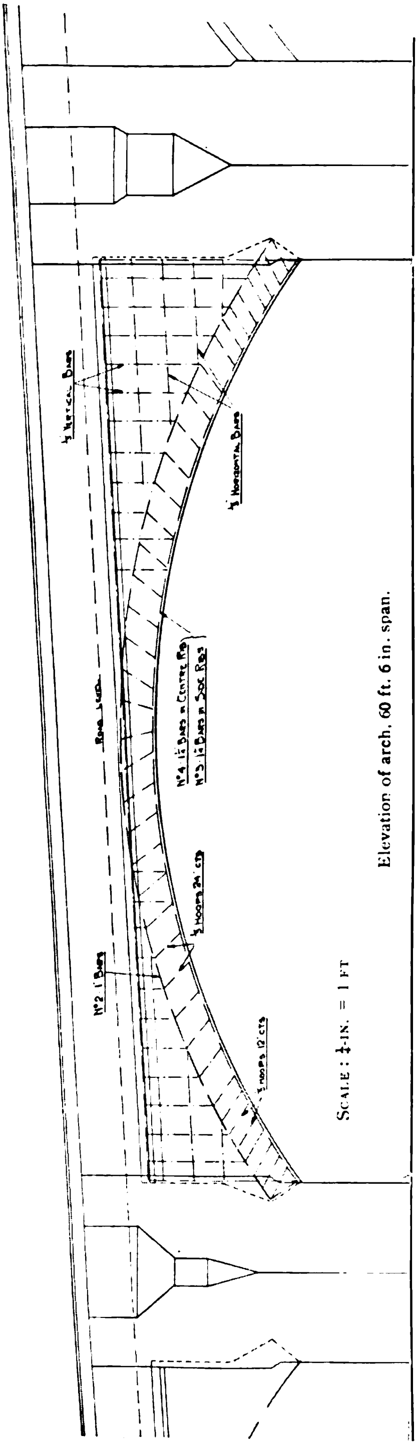
RECONSTRUCTION OF HAYDON BRIDGE.

COTTAGES AT NEWBIGGIN, MADE OF CONCRETE BLOCKS.

WE are pleased to observe the greater tendency of late to use concrete blocks in domestic work. There is no doubt that in districts where economical materials can be obtained suitable for aggregate, the concrete block will be found to be a most useful and economical substitute for brick and stone work. The simplicity of the operations for turning out concrete blocks and the speed of output are such as should recommend this material as a suitable medium for the erection of domestic, factory and engineering works.

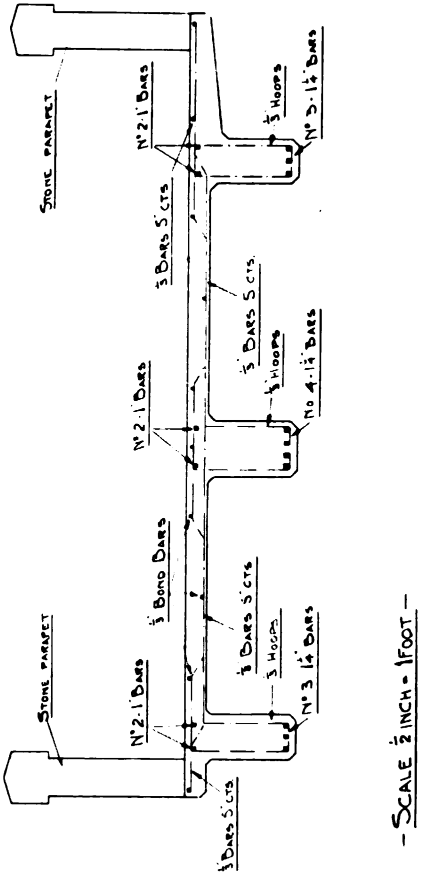
Concrete blocks in appearance and durability are excellent.

We have on many occasions shown examples of work executed in concrete blocks, and on page 690 we present illustrations of cottages built of concrete blocks made on the "Winget" block-making machine for the Newbiggin Colliery Co., Ltd.



Elevation of arch, 60 ft. 6 in. span.

Scale : 1/4-in. = 1 ft



Section of arch.

Reconstruction of Haydon Bridge.

Six hundred of these houses are to be built in all, which speaks volumes for the advantages of this method of erection. In our illustrations we show the front and back elevations of the first two rows. The neat compact appearance of these houses compares most advantageously with the usual style of buildings in colliery villages.

The height of the buildings from the

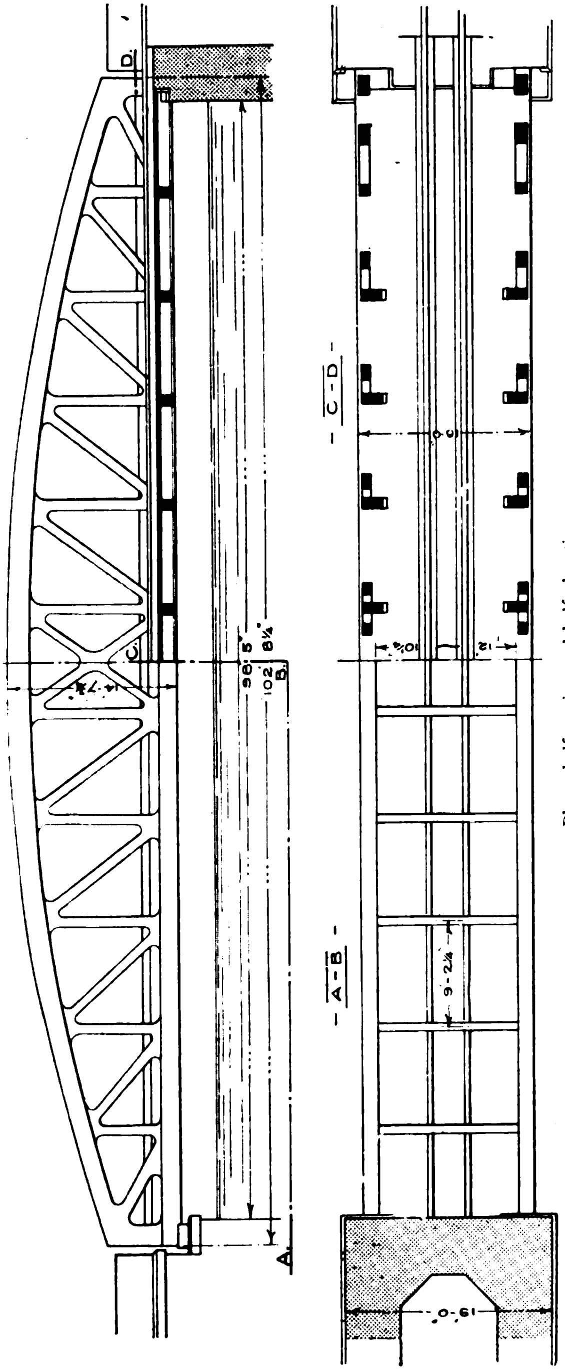
ground floor to the tie beam of roof is about 17 ft. 6 in., and each contains one large living room with a scullery behind and three bedrooms above.

The internal partition walls and party walls are built with solid concrete blocks, and the external walls with two 4½-in. solid blocks built 2 in. apart to form a continuous cavity, and bonded with wrought iron ties, galvanised. The total thickness of wall is, therefore, 11 in. The external face is "rock," and the appearance of the work is excellent.

Concrete Block Cottages at Newbiggin.
(A group from a series of six hundred in course of erection.)

The window and door-heads and steps are all concrete, the long heads and sills being reinforced with steel rods. The method of building the outer walls with a continuous cavity precludes all possibility of damp walls. The tiling of these houses is executed with "Eternit" tiles, which are composed of cement and asbestos.

In making the blocks for the outer walls, the "Winget" machine makes both the inner and outer 4½-in. leaves at the same time.



Plans, half section and half elevation.
BOWSTRING BRIDGE AT MONTESQUIEU.

In making these blocks, Portland cement was used in the proportions 5 to 1, the aggregate used being crushed quarry waste.

The architect for the work was Mr. Walter M. Redfearn, engineer to The Newbiggin Colliery Co., Ltd., and the whole of the blocks are made on "Winget" machines supplied by the U. K. Winget Concrete Machine Co., Ltd., of Newcastle-on-Tyne.

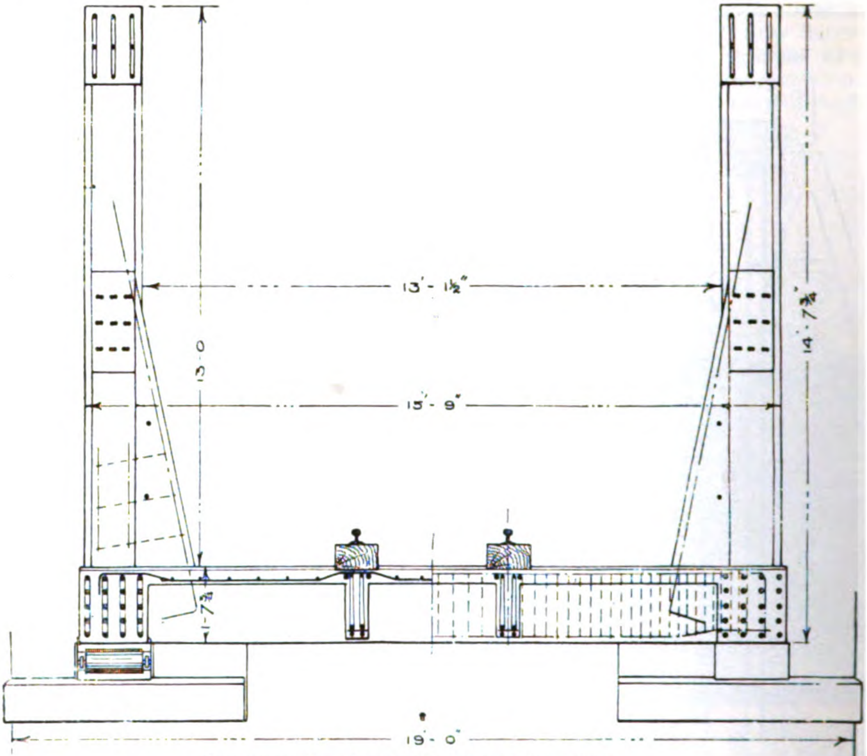
The concrete blocks are being made by the Newbiggin Colliery Co., and the erection of the houses is carried out by themselves without the intervention of a contractor.

BOW-STRING BRIDGES IN FRANCE.

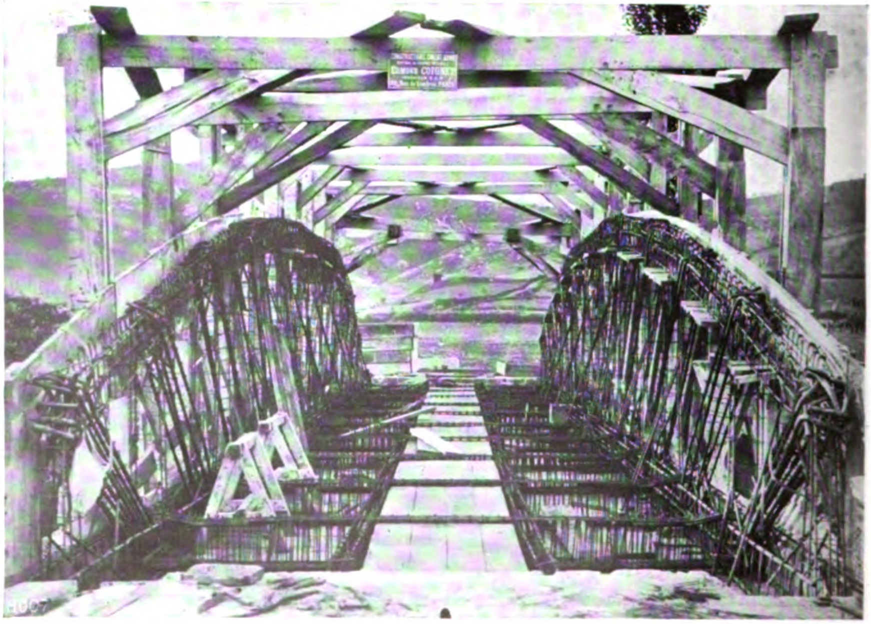
Up to the present it has been customary to execute bow-string bridges only in steelwork, but the illustration on page 686 shows a bridge built in reinforced concrete, on this system of construction, by Mr. Edmond Coignet, at Sabarat (Ariege), for the South Western Railway, and we understand that he is preparing for the execution of several very extensive bridges to be constructed after this type.

The elevation, plan and section shown on pages 691 and 692 are of another similar bridge, which is now in course of erection for the same company at Montesquieu. The only difference between these two bow-string bridges is that the first has a span of 20 metres (65 ft.), while the second has a span of 30 metres (98 ft.). The abutments of the bridges are made in ordinary rubble masonry.

It will be seen from the illustration that this method

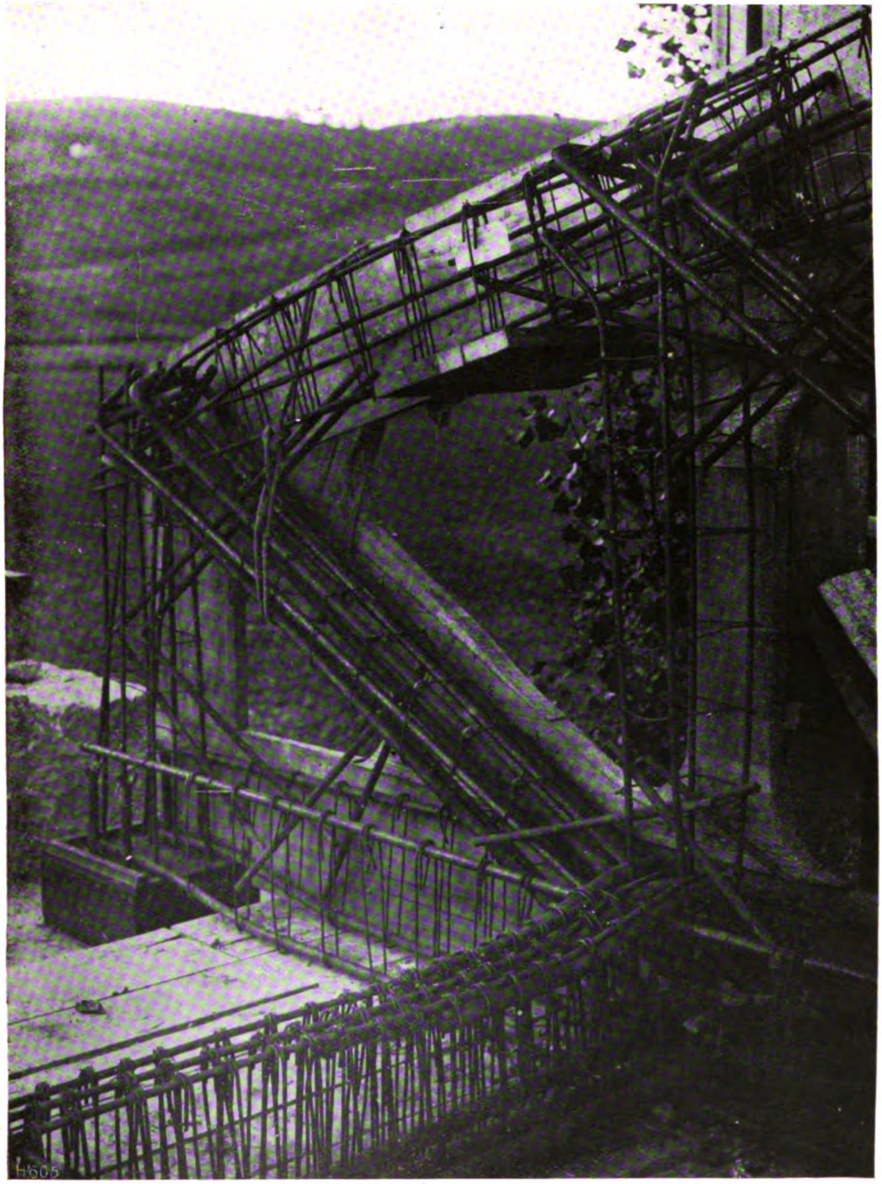


SECTION OF BOW-STRING BRIDGE AT MONTESQUIEU



View of the steelwork in position.
BOW-STRING BRIDGE AT SABARAT (ARIÈGE).

of construction is simply an enlarged form of the ordinary Coignet-beam, known as the "beam of uniform strength." The shear members, which in an ordinary beam are composed of single bars inclined at an angle of 45°, are represented here by a group of bars hooked on to the upper portion of the bow-string, which is in compression.



Detail of the steelwork.
Bow-string Bridge at Sabarat (Ariege).

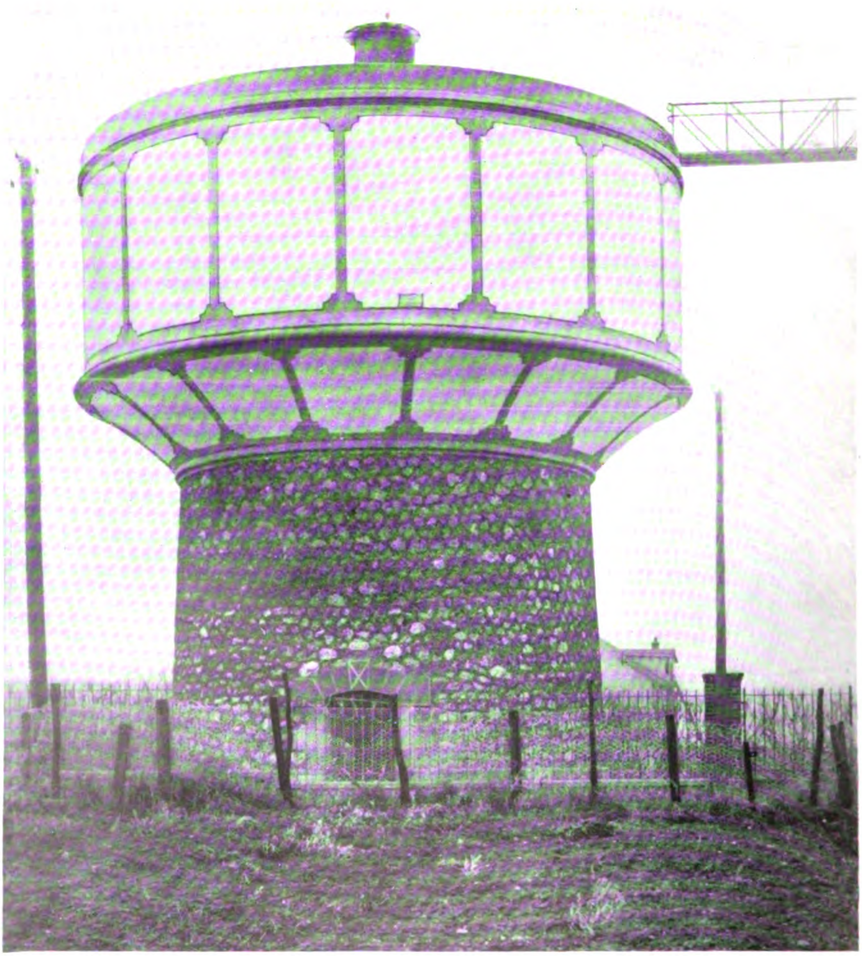
NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE ELEVATED TANK AT NANTERRE, PARIS.

REINFORCED concrete is now very extensively used on the Continent for reservoirs and tanks. In fact, we are informed that the tendency is to adopt reinforced concrete almost exclusively for this class of work, in preference to steel, owing to its much greater economy and also because it requires no maintenance.



REINFORCED CONCRETE TANK AT NANTERRE, PARIS.

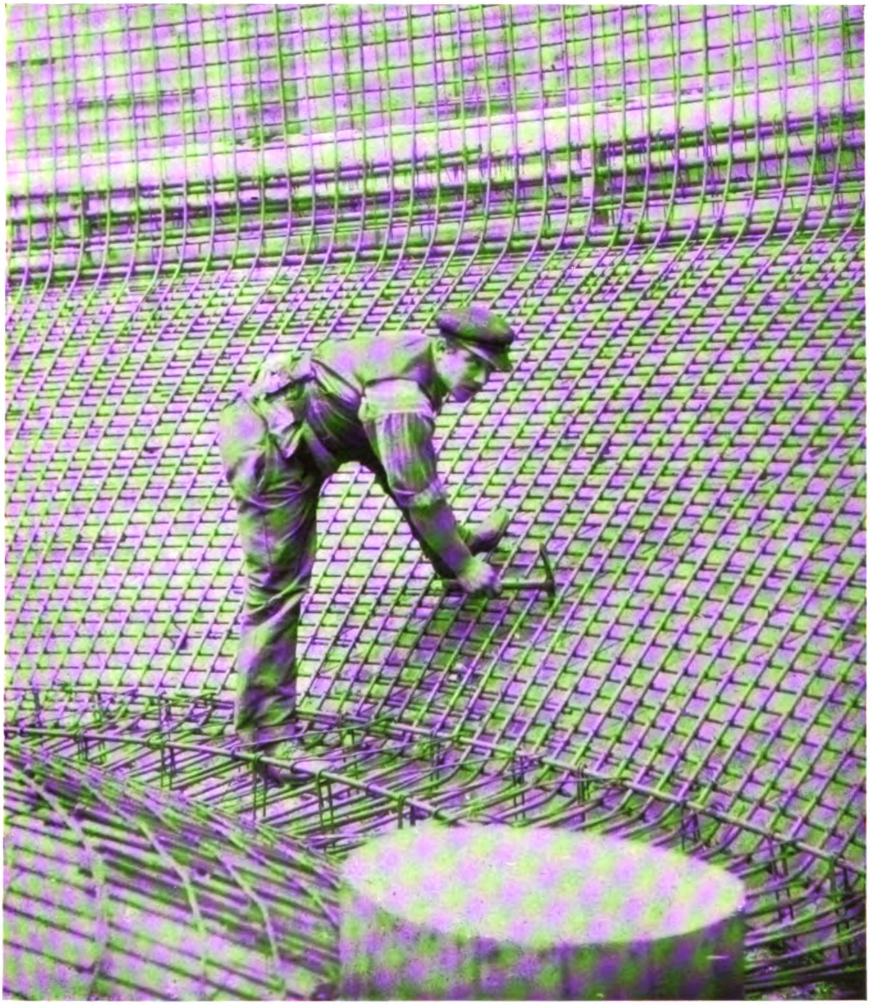
We herewith reproduce a photo of a large tank recently constructed by Mr. Edmond Coignet, on his system, for the Compagnie Générale des Eaux, at Nanterre, Paris.

The tower itself, supporting the tank, is made of rubble masonry. The capacity of this tank is 500 cubic metres (about 110,000 gallons).

It will be seen from the illustration on page 694 that the bottom of the tank is partly cantilevered off the tower, the inside portion of the bottom being made in the shape of a dome, in order to resist the pressure of the water without having recourse to beams.

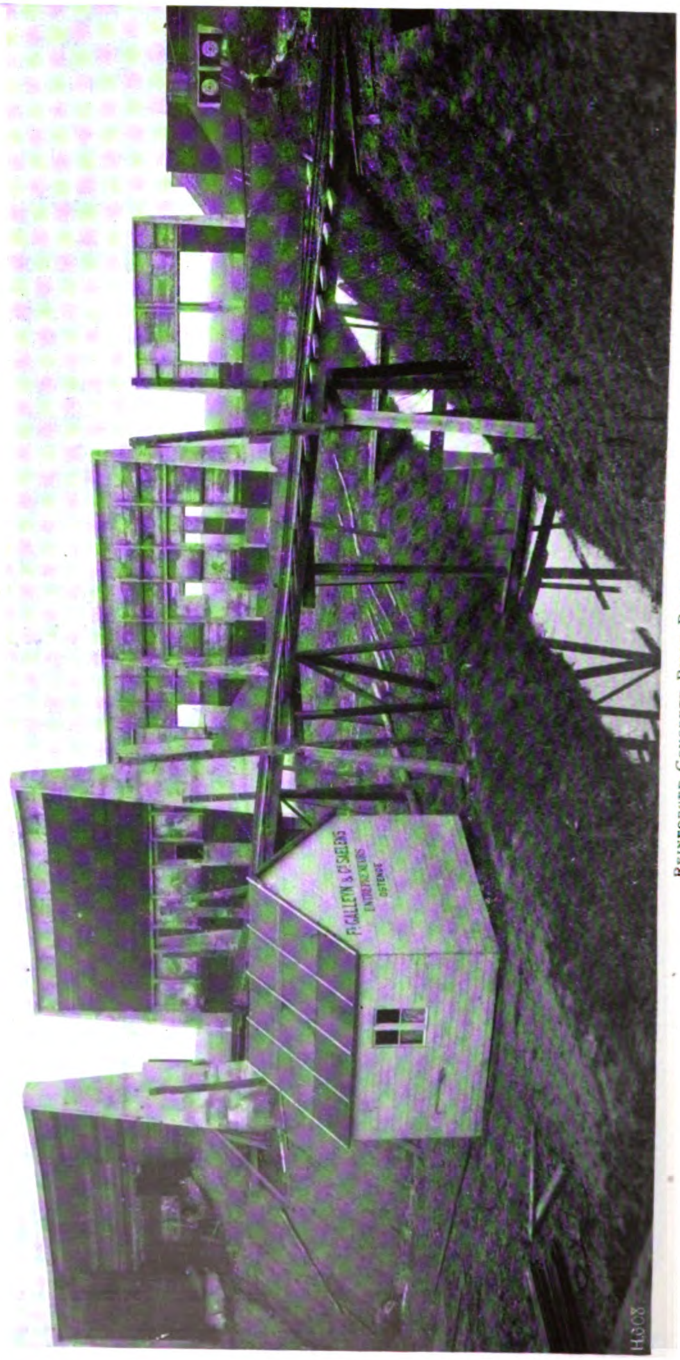
The roof of the tank is also in the shape of a dome, and the thrust of this dome is taken by a circular, as shown.

The illustration on this page gives the reinforcement of the cantilever portion of the tank, also showing the circular beam supporting the walls of the tank, and calculated to resist the pressure of the water.



View showing reinforcement in position.
Reinforced Concrete Tank at Nanterre, Paris.

We are informed that this is the most economical manner of making a reinforced concrete water tank of this capacity, owing to the fact that the panels are not more



Reinforced Concrete Rifle Range at Ostend.

than 4 in. or 5 in. in the thickest part, and very few beams are required. The storage capacity is also larger than if the tank was made of any other shape.

REINFORCED CONCRETE RIFLE RANGE AT OSTEND.

THERE seems to be no end to the various uses to which reinforced concrete can be applied. On page 696 we show an illustration of a large rifle range at Ostend, built entirely of reinforced concrete on the Hennebique system.

The height of the stands is 12 metres 50 (41 ft.) and they are 18 centimetres (7 in.) thick. The supports of the stands are also made of reinforced concrete.

The photograph from which our illustration is made was kindly lent us by our French contemporary *Le Béton Armé*.

CONCRETE BLACKBOARDS FOR SCHOOLS.

CONCRETE as a material for school blackboards is said to be a great improvement over any other kind of material, even slate. The foundation of the new kind of board is concrete applied to an ordinary brick or wire-lath wall. The finish is liquid concrete, mixed with very finely divided carbon black pigment. It gives a smooth surface, which consumes very little chalk, and eliminates chalk dust to a great extent. Its most important feature, however, is the fact that it presents an absolutely dead finish, without reflection, making it possible to see what is on the board from any angle of the room.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Reinforced Concrete at the London County Council School of Building.—We are pleased to report that this school has arranged for a course of lectures on "Reinforced Concrete: Practice and Design," to take place this winter, the lecturer being Mr. H. Kempton Dyson, the Secretary of the Concrete Institute.

We are informed that Mr. Dyson intends giving his students a thorough grounding in both the practice and theory of the subject. The course it is proposed to arrange under three heads—namely, theory, practice, and workshop experience. Those who are wishful of designing reinforced concrete will take the practical side of the subject, such as foremen, clerks of works, surveyors, and craftsmen will be required to attend only the lectures on practice and the workshop experience. The lectures will touch on all phases of the subject. Those on "Construction of Reinforced Concrete and Quantities of Same" will deal with the history and development of reinforced concrete, materials, tools and appliances, making of concrete and manufacture of reinforcing steel, centering, the actual work of construction, architectural treatment and finishings, quantity taking and estimating for reinforced concrete work, etc.

The lectures on "Theory and Design of Reinforced Concrete" will deal with the elastic theory of materials, experimental data, bending moments, shear stresses, beams, slabs, walls, columns, arches and domes, chimneys, reservoirs, tanks, bins, caissons, retaining walls, dams, pipes, sleepers, fence posts, poles, temperature stresses, rules and regulations, and practice in design.

The "Workshop and Laboratory Practice" is intended to supplement the lectures on practice and theory, and will deal with cement, its properties and testing; properties of stones and other aggregates, sand, water and steel; concrete proportioning and making; steel manipulation; making of centering and moulds; tests on concrete and steel; porosity; tests of structural members of reinforced concrete, the making of which affords practice in construction; bending moments; shear; adhesion, etc. The course will be amplified by experiments, diagrams, lantern slides, specimens, models and the use of testing plant. An endeavour will be made to visit works in course of construction so as to acquaint students with actual working conditions. The time of the lectures will be from 7.30 to 9.30 p.m.

It will be endeavoured to make the course of real value to those even who have had considerable experience in design and practice in reinforced concrete construction, so there should be a goodly attendance, especially as the fees are most moderate, being for those earning over 30s. per week 10s. the session, and for those earning 30s. per week or less 4s. 6d. the session, which fees include the whole or any of the classes in every subject held at the school; moreover, apprentices, learners, and improvers under twenty-one years of age are admitted free to the school. Those who think of joining should communicate with the Secretary, L.C.C. School of Building, Ferndale Road, Brixton, S.W.

In connection with this course a special introductory lecture is to be given on "The History and Development of Reinforced Concrete," by Mr. Kempton Dyson, on September 27th, at 7.30 p.m.

Tests on Bonna Pipes.—Two instructive tests have just been made on one of the joints of the pipe main which is now being laid for the Corporation of Swansea. This main is built in Bonna's system of steel pipes reinforced by a double coating of reinforced concrete; it is 24 in. in diameter, and designed to support a working pressure of from 1 to 500 ft. head.

Two pipes were placed in a testing machine and jointed together in the ordinary way. The first test, made on July 21st, was on the unfinished joint—that is to say, on the corrugated steel ring, caulked in with bitumen yarn and lead tubes. The pressure was put on and run up to 750-ft. head, or 325 lbs. per sq. in. Bonna's unfinished joint was behaving perfectly when one of the joints of the testing machine gave way.

This was repaired and the joint completed by concreting over the caulked lead joint, the ordinary reinforced concrete collar of the Bonna system, and, after standing until July 28th, was tested this time up to 1,100-*ft. head, or 475 lbs. per sq. in.* A similar accident occurred again; one of the joints of the testing machine gave way, but both the Bonna joint and the two pipes showed no signs of having the least suffered from this very heavy strain.

The tests were carried out under the supervision of Mr. Wyrill, the Corporation Engineer of Swansea, who was delighted at the result, in the presence of Mr. Schenk, Chief Engineer to the Swansea Harbour Trust, Mr. Owens, R.E., Mr. White (of Glenfield & Kennedy), Messrs. R. Descroix and A. L. Lanseigne.

The cement employed was of the "Ferrocrete" brand, supplied by the Associated Portland Cement Manufacturers. The testing machine, designed only for a pressure of a thousand feet, and which behaved very well considering, was supplied by Messrs. Glenfield & Kennedy, of Kilmarnock.

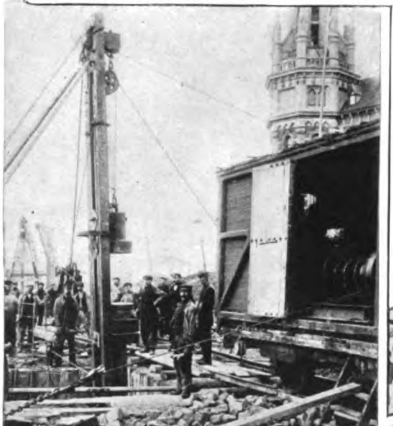
Town Planning Conference.—The Royal Institute of British Architects has decided to organise a conference to study the questions involved in the improvement and extension of our cities, with special reference to the artistic and constructional problems involved. This conference is to be held in London during the week 10th—15th October, 1910. The conference will be open to architects and to all others, including ladies, who are interested in the subject of town planning. Full particulars of the conference will be furnished on application to The Secretary-General, Town Planning Conference, Royal Institute of British Architects, 9 Conduit Street, London, W.

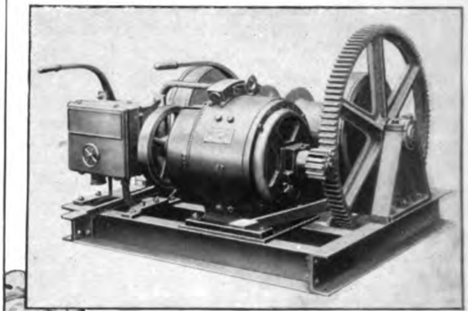
Annual Meeting of American Society for Testing Materials.—The annual meeting of this society was held at Atlantic City from June 28th to July 2nd inclusive. After general business had been attended to a number of interesting papers and reports relating to cement and concrete were presented. Mr. Richard L. Humphrey, President of the National Association of Cement Users, made a progress report on standard specifications for cement, and also presented the progress report of the Committee on reinforced concrete. Accounts were given of various tests on concrete arches and prisms for the New York State Barge Canal, on reinforced concrete columns, and on structural materials. One day was devoted to testing machines and apparatus.

Meeting of the Association of American Portland Cement Manufacturers.—A representative gathering of the leading manufacturers of Portland cement in the United States met at Chicago on June 13th, 14th and 15th to take part in the convention which was formed for the purpose of discussing matters of importance to the cement industry in America.

In the discussion following the report of the Committee on Publicity, the presentation of the three great purposes of the association were brought up, namely, (*a*) the question of publicity for the advancement of the general use of cement by broadening the markets for this material, and the development of the industry as a whole; (*b*) protection in the sense of watchfulness as to adverse legislation in Congress and building codes throughout the United States, and in the unwarranted attacks on cement as building material that might be made by other bodies advocating the use of materials other than cement; (*c*) the progress made as outlined in the reports on scientific research covering the use of concrete in cold and hot weather; the proper testing for fineness and tensile strains, and the guaranteeing of all cement made by the members when accompanied by a certificate from an association laboratory which it was hoped at some future time to establish.

UNIVERSAL JOIST STEEL SHEET PILING





ILLUSTRATIONS SHOW 15in. by 43lb. UNIVERSAL JOIST STEEL SHEET PILING BEING DRIVEN AND PULLED AT ANTWERP. IT IS BEING USED FOR SINKING 160 PITS THROUGH OLD FOUNDATIONS, SAND, AND MADE-UP GROUND.
THE PILES ARE WITHDRAWN AND RE-USED A LARGE NUMBER OF TIMES, AND DRIVEN WITH ONE OF OUR DOUBLE-BARRELLED ELECTRIC WINCHES AS SHOWN ABOVE.

THE BRITISH STEEL PILING COMPANY,
DOCK HOUSE, BILLITER ST LONDON. E.C.

The Cost of Damp-courses.—Attention was recently directed in these pages to the advantages of Ceresit as a waterproofing material. Although only recently introduced into this country, it has already secured a considerable sale, with results highly satisfactory to the users, and it has been adopted by H.M. Office of Works and a large number of public bodies and railway companies. Our attention has now been called to a direction in which Ceresit can be used to advantage and a very considerable saving effected—that is, in the construction of damp-courses. According to figures placed before us, a damp-course of asphalte, either horizontal or vertical, three-quarters of an inch thick in two layers, costs from 4s. 6d. to 5s. per yard; slate costs 2s. 6d. to 3s. per yard; while Ceresit costs only 1s. 9d. per yard. These are figures given to the British Ceresit Waterproofing Co., of Caxton House, S.W., by one of its customers, a large contractor, who points out that Ceresit has this added advantage—that, whereas in the use of asphalte the work must be done by sub-contractors, who bring their own workmen and cannot always be relied upon for time, Ceresit, needing no special or skilled labour, can be used by the builder's ordinary staff.

Cement Wash.– Recipe for cement washing for the outside of lighthouse towers.—Take three parts of cement, clear sand one part, and mix them thoroughly with fresh water. This will give a grey or granite colour, dark or light, according to the colour of the cement. If a brick colour is desired, add enough venetian red to the mixture to produce that tint. The cement, sand and colouring matter must be mixed together. If white is desired, the walls, when new, should receive two coats of cement wash and then whitewash. After the work has received the first coat a single coat every three or four years will be sufficient.

It is best to thoroughly dampen the wall with clean, fresh water and follow immediately after with the cement wash. This course will prevent the bricks from absorbing the water from the wash too quickly, and will give time for the cement to set. Care must be taken to keep all the ingredients of the cement wash well stirred during the application of it. The mixture must be made as thick as it will admit of to be conveniently put on with a whitewash brush.—*Cement Age.*

Cement Floors over Steamship Tanks.—An innovation has been introduced by the Pittsburg Steamship Company and Cleveland-Cliffs Iron Company, according to *Cement Age*,—in the form of a cement floor over the tank tops on the smaller and older boats of the fleets. Heretofore a wooden floor was used in these boats, but the pounding of the clams on the wood broke the floors, and the cost of keeping the floors in repair was immense. The officers of these two companies finally hit upon the concrete flooring as a remedy, and it is working out in a most satisfactory manner, for the concrete can stand all the wear and tear of the heavy clams and show not the slightest ill-effects. The Pittsburg Steamship Company has the cement flooring in about half-a-dozen of its boats, and the Cleveland-Cliffs Iron Company has them on two ships. One of the masters is quoted as follows concerning the practical features of the experiment:

"The wooden flooring that formerly covered the tank tops in our boats didn't last any length of time, so badly did the clam buckets hammer it, and it cost between two and three thousand dollars every season to make repairs on each ship. Now, since I have had the cement floor in my ship, we have no trouble, and in my belief the floor will last as long as the vessel. It is a mighty clever idea."

Associated Portland Cement Manufacturers and the Territorials.—The Associated Portland Cement Manufacturers (1900), Limited, of Arlesey, have issued the following notices to their employés who belong to the Territorial Force. The terms are well worthy of the notice of all industrial firms:

TERRITORIAL FORCE.

Members of the staff joining this Force will receive the necessary leave for eight days of their compulsory attendance in camp, in addition to their usual holidays.

It is the intention of the Board to renew this order year by year during the whole term of enlistment, so far as the circumstances of the company's business will permit.—July 14th, 1910.

Any hands joining the Territorial Force will be granted leave of absence for the period of their annual training, and will be taken on again at the end of that period, and an allowance by the company will be made for the current year during the annual training at the following rates: Married men, 10s. per week; single men, 3s. per week. (This is in addition to the Government allowance.)

It is the intention of the Board to renew this order year by year during the whole term of enlistment, so far as the circumstances of the company's business will permit.—July 14th, 1910.

TRADE NOTES.

The Armoured Tubular Flooring Co., Ltd., are at present laying in their patented system of reinforced concrete to the floors in the following buildings:—Imperial Court, Knightsbridge, S.W.; extensions to refinery in Rotherhithe; Fishguard Bay Hotel and goods offices, Swansea, for the G.W.R.; offices for the N.E. Railway in Newcastle-on-Tyne; Post Offices in Dublin, Belfast, Wrexham and Keighley; schools at Chelmsford, Handsworth and Barnstaple; brewery at Reading and Houghton-le-Spring; bank in Stockton; Liscard Library; factory in Belfast; soldiers' home at Newbridge; Royal Infirmary in Sheffield; paper mill at Keighley; restaurant and factory in Birmingham, etc., etc.; whilst current specifications provide for the introduction of this system in many other important public and private works.

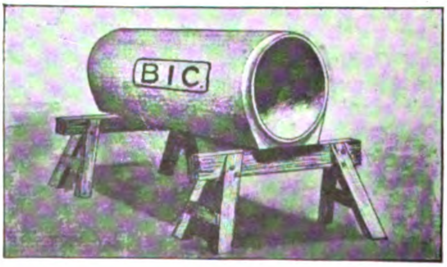
The Yorkshire Hennebique Contracting Co., Ltd, inform us that they have just secured the contracts for two large bridges over the main lines of the L. & Y. and G.C. Railways at Ashton-under-Lyne in connection with the extension of Richmond Road. The bridges are to be erected in reinforced concrete on the Hennebique system.

Branch Office of Messrs. William Moss & Sons, Ltd.—We understand that Messrs. William Moss & Sons, Ltd., of Queen Anne's Chambers, Westminster, who are the owners of the Pohlmann system of concrete reinforcement in the United Kingdom, have, owing to the success of this system of reinforcement, found it necessary to establish a branch office in the Liverpool and Manchester districts, and have therefore appointed Messrs. Mould & Brown, of Devon House, 19 Whitechapel, Liverpool, as their local representatives.

"BIC" BRITISH "BIC"
IMPROVED CONSTRUCTION CO., LD.
TELEPHONE: 2531 VICTORIA. TELEGRAMS: "BICONCRETE, LONDON."
47 VICTORIA STREET, WESTMINSTER.

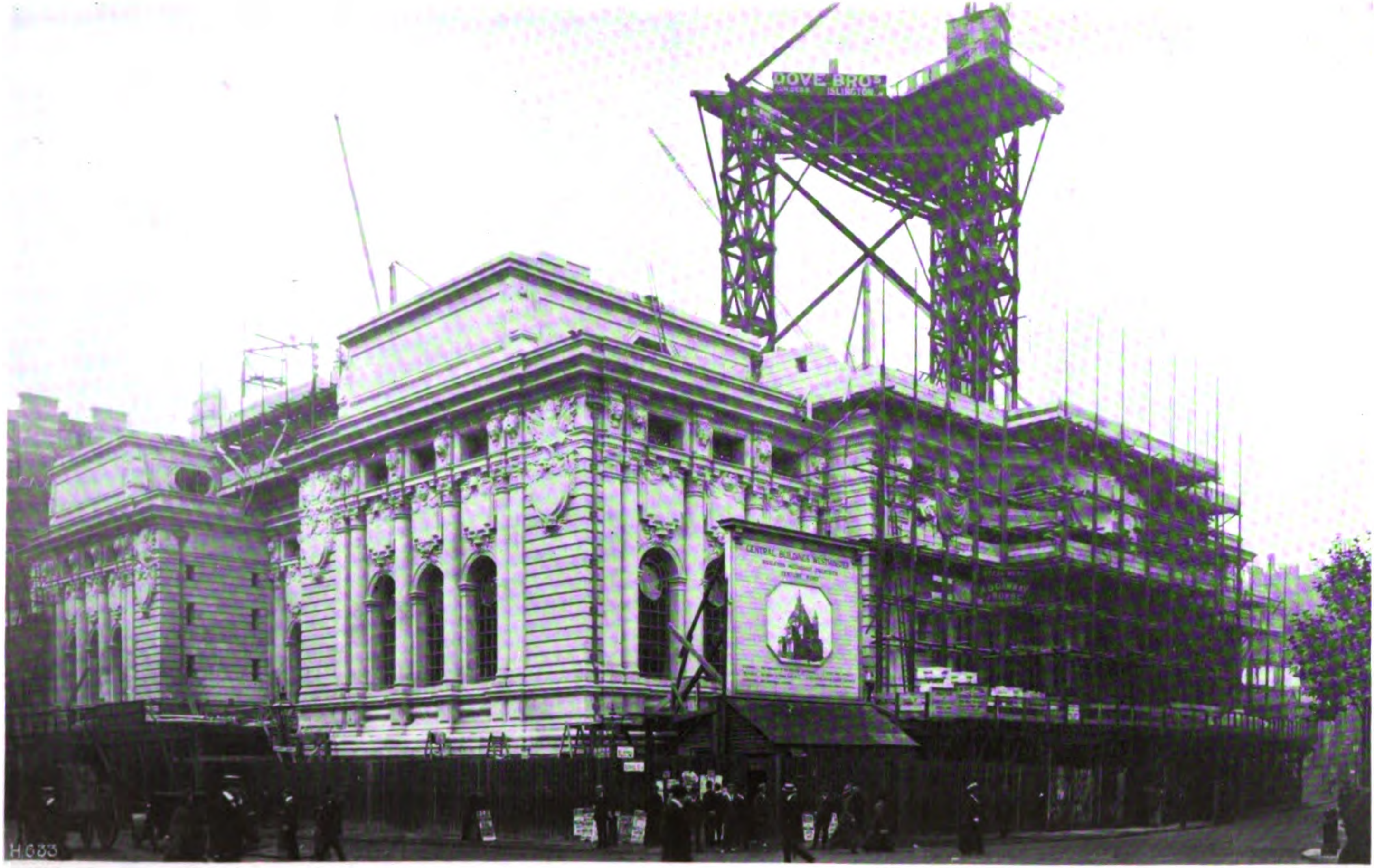
Flat-based Concrete Pipes
Three feet long to Twelve feet long.

Breeze Partitions
Reinforced Sleepers
Telegraph Poles



Porous Pipes
Concrete Beams
Hollow Floors

SPECIALITY:—INVENTORS' DESIGNS CARRIED OUT TO ORDER.



View in course of construction.
THE WESLEYAN HALL, WESTMINSTER.

Frontispiece
(opp. Contents).

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 10. LONDON, OCTOBER, 1910.

EDITORIAL NOTES.

THE INSTITUTION OF CIVIL ENGINEERS AND REINFORCED CONCRETE.

AFTER having for many years treated reinforced concrete with indifference—not to say hostility—the Council of the Institution of Civil Engineers was eventually persuaded last year to appoint a Special Committee to inquire into the use of this material, with a view of obtaining a more accurate knowledge of its qualities. We welcomed the appointment of the Committee, although we could not but call attention to the fact that it unfortunately was mainly comprised of engineers who had little or no experience of reinforced concrete, and we must again express our regret at this somewhat short-sighted policy in making unsuitable nominations to the Committee, more particularly as there are quite a number of the members in the Institution to draw upon who could have done most useful work on an inquiry of this kind.

THE INSTITUTION'S INTERIM REPORT.

THE Committee has now published an Interim Report, which claims our close attention. We have dealt with it at considerable length in the first article of our current issue, and have presented certain extracts. For a publication issued on behalf of the premier engineering society of the world the report is, however, unfortunately a most disappointing one. We will not cavil at the absence of any specific findings, although the Committee has been sitting for over a year, and although there are many matters pertaining to the subject on which definite opinions could easily have been given at this stage, without awaiting the results of the research work proposed. We expected, however, that the summaries presented in the Interim Report would have been complete ones, exhaustive, reliable, and useful, and printed in a clear and tabular form.

There are several distinguished members of the Committee fully capable of preparing a clear analysis and directing the preparation of proper summaries on any technical subject, whether they happen to be acquainted with the character of the data or not. The Institution has ample funds to engage several first-class compilers, and need not be parsimonious in its printing bill for the somewhat expensive tabular matter necessary. There is, of course, no reason to complain as to the volume or bulkiness of the report, although the number of pages used do not tend towards conciseness, but what we do complain of are its shortcomings in every direction, its lack of clearness in analysis, and amateurish character. The report is not even " up-to-date," for our article on the legislative enactments, published in 1908, and reprinted with our permission in such a manner as to form an important feature of the report, has not even been amended so as to embody the latest changes and developments of foreign enactments.

As we mention at the conclusion of our article, the Interim Report wants completing and summarising before the inquiry proceeds with its programme; but we would even go further and say that it would be preferable if the Interim Report issued were merely considered in the light of a rough draft, and if an entirely new summary of fewer pages and greater utility were prepared to take its place. To arrive at a really practical result it would, however, be advisable to materially strengthen the Committee.

SUGGESTED STRENGTHENING OF THE COMMITTEE.

As to strengthening the Committee, it not only requires the addition of some well-informed members of the Institution, but representatives from kindred bodies. Three public departments are represented, why not the other parties concerned? We believe that the Institution was informally approached from several sides as to co-operation with societies having a knowledge of the subject generally or various special phases thereof, more particularly when the research work necessary has to be undertaken. Throughout the past decade, and in all matters relating to reinforced concrete, the Council of the Institution has taken up the attitude of polite negative, and just as it refused some years back to co-operate with the Royal Institute of British Architects when that body was holding an inquiry, so it has now again shown undue exclusiveness in the matter of this Committee. We should have thought the Royal Institute of British Architects, the Concrete Institute, the British Fire Prevention Committee, and the societies representing the municipal engineers should have been invited to assist. Their presence would have strengthened the Committee and probably resulted in much better work being done.

We are great admirers of the Institution of Civil Engineers as a whole, but its weakness in this rapidly moving age is the undue conservatism and exclusiveness of its Council, a failing rarely to be found amongst those great scientists and captains of industry, whose success is often largely due to their having an " open mind." Reinforced concrete has come to stay in this country, and has long been recognised as an economic and efficient material for every-day use in other countries. An interim report of this kind does not help the members of the Institution who have to employ reinforced concrete and look to their Council for comprehensive data issued in a concise form.

We would, therefore, urge that the whole question of reinforced concrete be now taken up energetically and thoroughly by the Council of the Institution, instead of in the half-hearted and unsatisfactory manner to which the Interim Report referred to bears indisputable evidence.

THE LATEST BRITISH STANDARD SPECIFICATION FOR PORTLAND CEMENT.

THE Engineering Standards Committee have again issued a revised edition of the Standard Specification for Portland Cement, the previous issue, we believe, having had a very large circulation. We note the subjects referred to in the revised edition cover several clauses in the specification.

The very difficult question of setting time of cement has again been dealt with, and we note that in the revised edition a stipulation as to the initial setting time for the cement has been introduced for the first time. This is a new feature of considerable importance, which we predict will be welcomed by the engineering profession; but we presume the limits of initial set given for the various grades of cement will be subject to revision after some experience. With our knowledge of the difficulties of regulating and maintaining the setting time of cement as specified for the various descriptions of cement in the British Standard Specification, we anticipate the manufacturers will find themselves confronted with still further difficulties now that the standard of initial set has also been included.

However, we presume the limits given for setting time generally are not intended to be read absolutely to the letter, but that a certain amount of overlapping is intended, without which commercial difficulties must inevitably arise with a material like cement, the setting time of which is subject to alterations through temperature and other climatic influence beyond human control.

We note that it is now suggested that the Vicat needle, an instrument which is universally adopted, is recommended in place of the 2½-lb. needle hitherto employed.

It would appear that the committee have also had under consideration the introduction of a clause in the specification to determine the amount of expansion exhibited by cement when submerged before being set, but no stipulation is inserted in the present revise. From the information at our disposal we had understood that expansion to a considerable extent was apparent with cement to which large quantities of gypsum had been added. As such cement is generally slow setting, it would appear the committee have attributed this, when apparent, to the result rather than to the cause, for we believe slow-setting cements which do not contain gypsum are not subject to expansion when immersed in cold water before being set.

Various additions and alterations have been made to the clause referring to chemical composition. A minimum lime content has been included, and provision has now been made limiting the total amount of sulphur present in any form, which will have the effect of excluding various descriptions of cement which have hitherto claimed to rank as Portland cement.

We notice that no alteration has been made in respect of fineness of grinding for Portland cement. The figures as they now stand, of 18 per cent. on a 180-mesh sieve and 3 per cent. on a 76-mesh sieve, are not in keeping with improvements which have been made in other directions in the quality of this product. We foresee the time when cement will be ground much finer than is now required by the present specification, it being well known that only the impalpable powder of the cement is of any real value. We think the user of cement has not up to the present given this point sufficient consideration, as the value of the article as a cementitious material is immensely increased through its extended covering power. We should hope to see in the next revise a considerable reduction in permissible residues on the sieves referred to in the specification.

It is a matter of regret that the Committee continue to make something more than a nominal charge for copies of the specification. In fact, the price has been advanced from 2s. 6d. to 5s. per copy. Furthermore, the specification is copyright, and it is impossible, therefore, for anyone interested to have copies printed and circulated at his own expense. We believe that in the United States and in other countries either no payment whatever is required for the official specifications or something quite nominal is charged to cover the cost of printing and postage, while it appears to be a fact that cement makers in these countries and others interested are permitted to reprint and circulate the specification over as wide an area as they may deem desirable. It seems to us that it is in the interests of the cement industry that no hindrance should be placed upon the widest circulation of the specification issued by our own British Standards Committee, and it is to be hoped that the restriction to which we now draw attention may soon be removed.

PERMANENT DOCKS ON THE EAST COAST.

In a previous issue we referred to the absence of a proper increase in our permanent dock accommodation for naval purposes. A letter of the greatest interest appeared in *The Times* during the summer, as to constructing docks on a large scale in the Solent, both for naval and mercantile purposes.

The suggestion is certainly one that should appeal both to our great shipping interests and to our naval authorities, and it is most extraordinary that this proposal had not been made years ago. From the naval point of view, however, what is urgently required are permanent docks on the east coast, but the replies of the First Lord of the Admiralty last session were again highly unsatisfactory as to the intentions of our naval authorities in this direction.

A good many conflicting reports have been published as to the British position in docks as compared with the German one, as far as the North Sea and the Channel are concerned. The following data may be considered reliable, as coming from an authority on the subject, and it will be seen that we are no longer in the first position as regards docks for modern warships in the critical areas of our coasts.

The dock accommodation in the two countries is as follows:

For completed docks.

Kiel.—Two Admiralty and one private floating dock (for 40,000-ton ships).

Wilhelmshaven. — Three Admiralty docks.

Bremen.—One private dock.

Hamburg.—Two private floating docks (for 35,000 ton ships), one of which is, however, not yet in commission.

Devonport.—Three Admiralty docks.

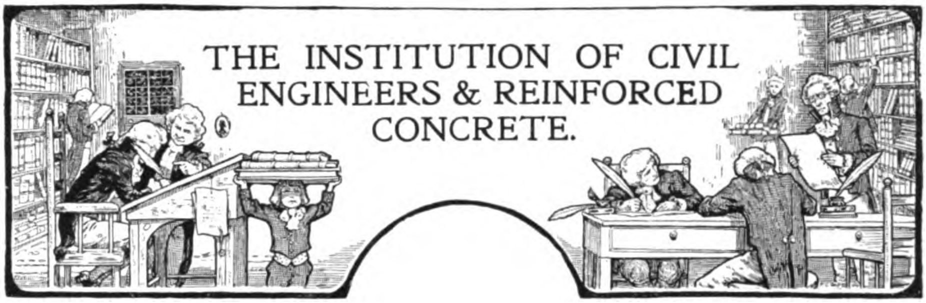
Portsmouth.—One Admiralty dock (available at certain hours).

Hebburn.—One private dock.

There are six other private docks on our coast that would probably take damaged *Dreadnoughts*, but they are not on the North Sea or the Channel.

Two further Admiralty floating docks are yet in the builders' hands, and they are stated to be designed only for 33,000-ton ships. Their probable position is Sheerness and Portsmouth, but it is unlikely that they will be in commission until 1912.

The construction of an additional dock at Rosyth, the completion of which is only due three or four years hence, is entirely insufficient. Floating docks are makeshifts indeed. What the nation really requires is some seven additional docks on the east and south coasts suitable for taking ships of the *Dreadnought* class, and it seems almost incredible that financial considerations should weigh so heavily in matters of such national importance.



THE INSTITUTION OF CIVIL ENGINEERS & REINFORCED CONCRETE.

Preliminary and Interim Report of the Committee on Reinforced Concrete.

The Institution of Civil Engineers, which has at last taken up the question of reinforced concrete and appointed a Committee to deal with the subject, has issued an Interim Report which we deal with below.—ED.

THE Special Committee appointed by the Council of the Institution of Civil Engineers, on December 15th, 1908, "to enquire into the use of reinforced concrete, with a view to a more accurate knowledge of its preparation, strength, properties, and use in engineering work being arrived at," have made a preliminary report of their proceedings up to June, 1910, which report was adopted by the aforesaid Council on June 22nd and has just been published.

The Committee, as we have already recorded in our columns, consists of the following:—

Sir William Matthews, K.C.M.G., *Chairman.*
Sir John Wolfe Barry.
Mr. Bertram Blount.
Mr. B. Hall Blyth, M.A.
Mr. R. Elliott-Cooper.
Mr. M. Fitzmaurice, C.M.G.
Mr. W. R. Galbraith.
Mr. James C. Inglis (*ex-officio*).
Mr. A. G. Lyster.
Mr. C. S. Meik.
Dr. W. C. Unwin, F.R.S.
Major R. N. Harvey, R.E. (*nominated by the War Office*).
Mr. Thomas Sims, C.B. (*nominated by the Admiralty*).
Mr. G. W. Willcocks (*nominated by the Local Government Board*).
Dr. J. H. T Tudsbery, *Secretary.*

In presenting this Preliminary and Interim Report, the Committee state their desire to draw special attention to the fact that up to the present stage their work has wholly taken the form of inquiry into the conditions under which reinforced concrete has been employed hitherto in engineering works in various countries, the views of engineers who have had special experience of its use, and the data so far available as the result of such experience, and of investigations which have been accessible to the Committee.

In the introductory note it is also stated that the Committee are not yet in a position to put forward recommendations or a pronouncement of views upon the subject, such as they hope to draw up later, but they consider it desirable and advantageous that the results of their inquiry up to the present time should now be communicated; and whilst they have taken every practicable step to verify the statements contained in this Report they must refrain from accepting responsibility for these.

The Committee assembled on February 1st, 1909, and have met frequently since then. At the outset of its proceedings it was resolved to collect, in the first instance, precise information of the principal systems of reinforced concrete construction now in use, setting forth their chief features and the general advantages claimed for them. This information forms "MEMORANDUM A" of the report.

The Committee then prepared a comparative analysis of specifications for work in reinforced concrete adopted by various leading manufacturers who employ the foregoing systems. This is given in "MEMORANDUM B."

There was also assembled for their consideration the Summary of Official Rules for the use of reinforced concrete in use in various countries, being an authorised reprint from an article published in our issue for July, 1908, Vol. III., p. 175. This forms "MEMORANDUM C."

PARTICULARS TO BE COLLECTED.

Proceeding to consider the nature of the information as to the actual facts bearing on the subject which the Committee should aim at procuring, it was decided that the following particulars in relation to the materials used and the calculations employed for reinforced concrete should be regarded as of primary importance :—

1. ***Materials.***
   - Composition of concrete and nature of aggregates.
   - Regulations as to mixing and placing.
   - Precautions in placing the reinforcing bars.
   - Quality of steel reinforcing bars, whether of mild, medium, or high-elastic limit steel.
   - Special notes of the use of indented, twisted, Kahn, or other patented forms of reinforcement.
   - Tests required in specifications of concrete and steel.
   - Requirements as to time allowed before removing moulds or centerings and whether these depend on temperature at the time.
   - Particulars of any loading tests of finished reinforced concrete works and of any observations of stiffness or deflection.
   - Notes of the use of any special moulding machines for reinforced concrete, such as "mono-concrete machines."
2. ***Calculations.***
   - Notes of any special methods of approximate calculation adopted.
     - Stresses allowed :—
       - For Concrete :—In compression.
         - In bending.
         - In shear.
         - Adhesion or bonding stress.
       - For Steel :—In tension and compression.
   - Methods of calculating the distribution of stress to concrete and reinforcing bars in columns.
   - Methods of calculating the lateral staying of longitudinal reinforcing bars in columns and distance apart of stays.
   - Rules adopted as to ratio of length to least lateral dimension in columns.
   - Rules for flat slabs adopted. For instance, such rules as that the greatest bending moment is assumed as W.L./12.
   - Methods adopted in calculating beams. Where the neutral axis is taken to be. What kind of distribution is assumed for the thrust on the concrete. Arrangement of reinforcement over supports when beams are continuous.
   - Drawings of any interesting details, such as junctions of beams and columns.

The Committee next proceeded to review the published experimental data bearing upon the properties of materials employed in reinforced concrete, and also those bearing upon the strength of beams and columns. A synopsis of these data is contained in "MEMORANDA D and E."

The next phase of the Committee's inquiry was to obtain information as to the general conditions under which reinforced concrete is now employed in engineering works, and the results of experience as regards the efficiency, stability, and permanence of such works.

For the sake of convenience the various works in question were classified under the following ten heads :—

Class 1.—Foundation walls.
Piled foundations.
Distributed or floating foundations.
,, 2.—Retaining walls.
,, 3.—Dams.
,, 4.—Marine Works: Piers, jetties, and quays.
,, 5.—Reservoirs and tanks.
,, 6.—Road bridges.
Class 7.—Railway bridges.
,, 8.—Culverts.
,, 9.—Warehouses—*i.e.*, buildings in which the structure is subjected to statical loading with but little vibration.
,, 10.—Factories—*i.e.*, buildings in which machinery is used, and where considerable vibration occurs.

SPECIAL EVIDENCE OBTAINED.

It being thought advisable at this stage to seek direct information with regard to the execution of reinforced concrete works from engineers who had had considerable practical experience in carrying out such work, on the invitation of the Committee a number of such engineers attended and gave evidence upon the following general questions, so far as these had come under notice in the course of their experience:—

1. The conditions under which contracts for reinforced concrete works carried out have been let.
2. The arrangements made with specialists, and the extent to which these furnish information on which contracts are based.
3. The responsibility of the specialists who furnish these data.
4. Experience as to the effect of use and age on reinforced concrete structures carried out by them.
5. The present condition of such works.
6. The extent of repairs and reinstatements which have been found necessary since the works were completed.
7. The loads on the works.
8. The tests applied, and how the proportions of the structures were determined to comply with the conditions to be provided for.

A synopsis of the evidence given before the Committee is given in "MEMORANDUM F," and a full report of the evidence and information given on special points of the inquiry is presented in "MEMORANDUM G."

SPECIAL REPORTS OBTAINED.

Simultaneously with the inquiries and investigations alluded to, the Committee proceeded to obtain definite and original reports by engineers appointed by the Committee for the purpose, upon certain reinforced concrete works in various countries, these works having been selected out of a large number considered by the Committee as likely to afford useful practical information. Carefully prepared instructions were issued to the reporters as to the points upon which information was desired. Up to June twelve such reports were received and are included in "MEMORANDUM H." Others are in course of preparation. "An endeavour has been made to render these reports comparable with one another as far as possible; and whilst it is obvious that they exhibit a considerable absence of uniformity, both in methods applied and in results obtained, and cannot be regarded as conclusive owing to the comparatively limited period of the existence of any substantial engineering work constructed in reinforced concrete, it is believed that the examinations afford useful and reliable information."

A bibliography of articles has been included bearing on the subject of reinforced concrete, which have appeared in recent volumes of the Minutes of Proceedings of The Institution of Civil Engineers. These are arranged in a similar manner to the Reports on Works.

ABSENCE OF ANY FINDINGS.

The Report proper concludes with the statement that before approaching the part of the subject consisting of the formulation of any opinion upon the various important questions involved, or the recommendation of any rules for general guidance in its use, combined as it must be with the principles of calculation applicable to the actual strength of reinforced concrete structures, as well as with the data relating to its constituents and preparation, the Committee have felt that there is a distinct lack of reliable information of a kind which can be readily adopted from a scientific point of view, with regard to tests and experiments on a working scale upon reinforced concrete structures of an engineering character.

"The Committee have now this important point under their consideration. It is naturally beset with considerable difficulty, especially in regard to the expense involved; but the Committee trust that any such difficulties may be overcome, and that they may be in a position without loss of time to supplement this preliminary Report by one containing their findings on the subject generally, as well as such recommendations in regard to rules and practice as their investigations may suggest."

THE CONSTITUTION OF THE COMMITTEE AND ITS REPORT GENERALLY.

The foregoing is an abstract from the Report, which it will be seen forms a general survey of the field and a reference to the detailed appendices or memoranda on various aspects of the subject. It is advisable to examine critically the documents embodied in this report, because these form part of the evidence upon which the Committee may come to a decision and pronounce with a show of authority that may have an important bearing upon the development of reinforced concrete, in view of its effect on the engineering profession, many members of which owe allegiance to our premier engineering institution. In the following, therefore, we shall remark upon the work of the Committee as embodied in the Report and review the memoranda attached thereto.

Firstly, in regard to the constitution it is to be regretted that there were not more members included who had had experience of reinforced concrete, and had paid special attention to the subject before this. The members (with two notable exceptions) of the Committee as a whole certainly seem to us to belong to the ultra-conservative element of the engineering profession. We say that not reproachfully, for it is a useful thing to have the subject examined in such a way, and the Committee seems to be going slowly and carefully into the matter, gradually acquiring knowledge and securing education in the subject, and in fulness of time may arrive at some interesting and valuable conclusions. We do not cavil at the progress made; the only matter for regret is that the Institution of Civil Engineers should have been so late in establishing a Committee of the kind. Abroad the subject has been taken up by Governments, municipal authorities, and technical societies fully ten years back, and even in this country the Royal Institute of British Architects' Joint Committee on Reinforced Concrete, under the chairmanship of Sir Henry Tanner, reported in 1907. In 1908 the Concrete Aggregates Committee of the British Fire Prevention Committee issued an interim report bearing on the subject, the Association of Municipal Engineers had a Joint Committee sitting on the question of Loan Periods, and, lastly, the Concrete Institute was formed to devote special attention to the subject. The latter event, in fact, seems to have awakened the Institution of Civil Engineers into a lively interest—unfortunately it seems the fate of that Society to act after most other Societies in connection with engineering and architecture have moved in any matter.

On the whole the lines upon which the Committee have made enquiry seem to be good, and if the execution came up to the programme as outlined above the Committee could at least have been said to have performed a valuable service; but the Report before us does not give evidence of such care and thoroughness in the "Memoranda" as was warranted by a publication of that stamp, and it must be set down that the performance does not come up to the promise.

SUMMARY OF SYSTEMS.

For instance, in "MEMORANDUM A," which is a summary of various systems of reinforced concrete, prepared by Mr. E. W. Hollingsworth, M.A., Assoc.M.Inst.C.E., the historical treatment is most casual and inadequate. No reference is made therein to Vaux, Thuasné, Wilkinson, Lambot, Dennett, Allen, Ransome, Brannon, Hyatt, Lascelles, Ward, Lindsay, Bordenave, Cottançin, de Tedesco, Lee and Hodgson, Jackson, Percy, Briggs, Mayol, Day, Meyenberg, Edwards, and Stuart. Indeed, practically the whole of names of note have been omitted. When it comes to describing systems of reinforced concrete employed in this country the list is also incomplete, the systems and firms included being :—Monier, Hennebique, Considère, Coignet, Melan, British Reinforced Concrete Engineering Co., Ltd.; Trussed Concrete-Steel Co., Ltd.; Patent Indented Steel Bar Co., Ltd.; British Concrete-Steel Co., Ltd.; Expanded Metal Co., Ltd.; Hodkin and Jones, Ltd.; Richard Johnson, Clapham and Morris, Ltd.; and United Kingdom Fireproofing Co., Ltd. What, we ask, have the following done that they should be excluded :—Stuart's, Bradford's, Wells, Cubitt's, Tozer's, Kleine, Moss, British Improved Construction Co., Leslie's, Siegwart, Empire Stone Co., Perfector Bar Co., Somerville, Lewis Consruction Co., Sidéolith, Homan & Rodgers, Columbian, Bonna, Herbst (or Armoured Tubular), Adamant, Chain Concrete Co., Potter (or Main), Wilkinson, and Williams? Some of them were in business long before and have been responsible for a far larger amount of work than some of those included. And lastly, what about the forms or principles of designs that do not aspire to the description of a "system" and yet by repetition have become recognised forms of design?

"MEMORANDUM B" is a comparative analysis of specifications for work in reinforced concrete adopted by the following firms: British Reinforced Concrete Engineering Co., Ltd.; Trussed Concrete-Steel Co., Ltd.; British Concrete-Steel Co., Ltd.; L. G. Mouchel & Partners, Ltd.; Considère Construction Co., Ltd.; Expanded Metal Co., Ltd., and Edmond Coignet, Ltd. Omitting the clauses affecting the erection of reinforced concrete structures, we give a summary of this analysis in form of an Appendix (see page 716). Again we have to protest against the inadequacy of the data for a true comparison of this nature by reason of the exclusion of so many specialists who have also had considerable practical experience. Of the analysis published we present some extracts (abbreviated) in tabular form, and note that our system of tabulation, as adopted for the legislative summary, has been wisely adopted by the Committee. We give the summary in the same order as published, though we think a summary where the firms' names are given in alphabetical order would have been more in place.

EXPERIMENTAL DATA.

"MEMORANDA D and E," which have been prepared by Mr. Edward William Hollingsworth, M.A., Assoc.Inst.C.E., deal with experimental data regarding (1) properties of materials employed in, and (2) beams and columns of reinforced concrete, respectively. We hope to be able to deal with these in detail in a subsequent issue, for the evidence there assembled may have an important influence on the findings of the Committee and upon the engineering profession. The numerous sources consulted and mass of material from which these memoranda are compiled has naturally resulted in very great compression, and, therefore, the data are mostly given without any of the explanatory and contextual references needed by the reader to draw correct inferences therefrom. The manner of presentation by the author is such, however, as to lead the casual reader to definite conclusions which would often be of an erroneous or perverted character. The memoranda, too, seem to us to convey a want of practical acquaintance with the subject which is needed to winnow the chaff from the corn, and also to put the facts in their proper relation and to comment correctly thereon. Curiously, the very valuable data obtainable in this country as to experiments regarding fire resistance have been overlooked. The results of fire tests happen to be the only systematically prepared ones available on the subject in this country, and, what is more, the only English ones that can be considered of international importance that have served as a basis for much that has been done at home or abroad.

SYNOPSIS OF EVIDENCE.

"MEMORANDUM F" is a synopsis of the evidence which was given before the Committee by the following witnesses: Messrs. Bertram Blount, W. H. Hunter, C. J. Jackaman, G. G. Lynde, A. G. Lyster, C. S. Meik, R. J. G. Read, F. E. Wentworth-Sheilds, W. W. Squire, P. C. Tempest, J. J. Webster and E. A. Wilson.

We reprint the following, which deals with matters of special interest to our readers:—

Employment of Specialists.—Specialists were employed for designing the reinforcement by *Mr. SQUIRE, Mr. READ* and *Mr. LYSTER;* also in some cases by *Mr. HUNTER* and *Mr. WILSON. Mr. WEBSTER* would design reinforced structures himself if his clients did not make any condition as to the employment of specialists.

Preparation of Designs.—*Mr. SQUIRE* issued specifications and outline drawings and invited tenders, both for ordinary construction and for reinforced concrete without restriction as to the system to be used. The calculations given by patentees were checked and in some cases modifications were introduced. *Mr. W. H. HUNTER* stated that in the case of the transit-sheds at Manchester, Mr. Mouchel had designed the reinforcement, but he himself examined the drawings and his staff checked the calculations. He considered that the engineer should go into the design himself. *Mr. E. A. WILSON* gave the loads and general dimensions for the Parkeston Quay. He considered it would be practicable and desirable to carry out reinforced concrete structures without going to a specialist. *Mr. JACKAMAN* stated that the engineer usually prepared mere outline designs, showing the general requirements of the work. The proper procedure was that the contractor should introduce the work through the medium of the engineer and supply the information the specialist might require. The specialist would then prepare a preliminary design and quantities which enabled the contractor to tender or prepare an estimate. If a design was not accepted, or reinforced concrete was not adopted, no charge was made by the specialist or contractor. *Mr. WEBSTER* would design reinforced structures himself if his clients did not make any condition as to the employment of a specialist. He designed the reinforcement of his works without assistance from specialists. *Mr. READ* would, if required, design reinforced concrete works without the aid of a specialist, but in London he would go to a specialist, as they had more experience of the material, and, moreover, particular patented systems might be applicable to particular works. He would check the specialist's calculations. *Mr. LYSTER* had all the detail drawings prepared by the specialists, who also determined the proportion of steel to concrete.

Methods of Contract.—*Mr. SQUIRE* stated that he issued duplicate specifications and outline drawings and invited alternative tenders, for ordinary and reinforced concrete work, without restriction as to system. As a rule, one contractor tendered only on one system. A licensee of the Hennebique Company was not allowed to work on any other system. Usually only one contractor was licensed in any particular locality. *Mr. WENTWORTH-SHEILDS* mentioned that the practice of licensing only one contractor in a particular district had been relaxed in recent years. *Mr. LYNDE:* Messrs. Nuttall were licensees of the Hennebique Company, and the licence might expire in two or three years. The original licence prevented licensees from tendering on other systems, but they were now allowed to do so if they wished. Mr. Lynde would give a price in the ordinary way for work in which the reinforcement was designed by the engineer, provided he had confidence in his ability. *Mr.*

WILSON: In tendering for the Angel Road Bridge the contractor might submit an alternative tender upon any system, but before his tender could be accepted he had to supply the whole calculations on which the design of the reinforcement was based. *Mr. JACKAMAN:* The contractor generally tendered in competition, which was limited to licensed contractors, of whom there were now a large number distributed over the country. Competition was limited to licensed contractors, and that was essential as experience was important. *Mr. WEBSTER* thought there were plenty of good contractors all over the country of sound reputation, who could carry out satisfactorily any reinforced concrete work, although they might not be licensees of any system. There was no difficulty in getting suitable contractors to tender for work which was not designed by specialists, although contractors licensed under some systems were not free to tender. *Mr. READ* mentioned that the contractor in most cases with which he had been connected was one of the Hennebique Company's licensees. *Mr. LYSTER* supplied the specialists with a general description of his requirements, and they obtained tenders for him from various contractors.

Responsibility of the Engineer and the Contractor.—*Mr. SQUIRE* said that the engineer was held responsible, but it was necessary to leave details to the specialist, such as the method of reinforcement and calculations of stress. *Mr. WENTWORTH-SHEILDS* thought that the responsibility must rest with the engineer. *Mr. LYNDE* considered the contractor and specialist jointly liable. The contractor was responsible for his work, and would be liable if failure was caused by bad work. If the failure was purely a matter of design, then the specialist was liable, by agreement. If the specialist made a mistake and it was found that the reinforcement in his bill of quantities was insufficient, then he was responsible to the contractor. *Mr. READ* stated that in the event of any failure in the reinforced concrete work, the contractor was responsible, if the contract were made with him. *Mr. JACKAMAN* considered that the specialist was responsible to the contractor for the efficiency of the design. The responsibility usually implied in a contract was carried by the contractor. *Mr. LYSTER* had always made the contractor responsible for the work. He had assumed the specialists to have a moral responsibility in important matters, and they had accepted it.

The other subjects dealt with and the general conclusions may be stated briefly as follows:

Relative Advantages of Reinforced Concrete and other modes of Construction. (Cost.)—*Mr. SQUIRE:* Saving on first structure at Bristol double that of subsequent works. *Mr. WENTWORTH-SHEILDS:* Alternative tenders for new dock at Southampton with quays on Hennebique system and with solid walls about equal. *Mr. HUNTER:* Reinforced concrete structures less costly than brick and steel. *Mr. WILSON:* At Parkeston a steel and corrugated iron shed on jetty was adopted as cheaper and lighter than a reinforced concrete one. *Mr. LYNDE:* Tender for reinforced concrete sheds received by a docks engineer 12 per cent. lower than for steel and corrugated iron construction. *Mr. WEBSTER:* In some cases a reinforced concrete jetty cheaper than of other materials. *Mr. READ:* Tank at Newton-le-Willows would have cost rather less in steel than in reinforced concrete.

(Rapidity of Construction.)—*Mr. HUNTER:* Progress as rapid as with steel. *Mr. LYNDE:* Jetty construction as rapid as to construct as with timber, but about 10 weeks lost at start. A large transit shed would be quicker to construct in reinforced concrete than in steel. *Mr. JACKAMAN:* Steel framing and corrugated iron shed would require rather less time than in reinforced concrete. *Mr. WEBSTER:* Longer to construct a jetty in reinforced concrete than in other ways.

(Durability.)—*Mr. SQUIRE:* Works at Bristol three years old showed no signs of failure. *Mr. WENTWORTH-SHEILDS:* A jetty near Southampton and the cold-storage warehouse had cost nothing for maintenance. The quay widening and coaling jetty showed considerable deterioration owing to the rusting of the steel, due largely to the misplacement of the reinforcement. *Mr. HUNTER:* No flaking off of the concrete, but expansion cracks had occurred in panelling of sheds. *Mr. LYNDE:* No failures and had spent nothing on maintenance. Never seen any flaking of the concrete, but had seen brown marks on the outside of the concrete in isolated instances. *Mr. LYSTER:* Trouble with expansion cracks in case of a shed, especially in the thin panel-walls. Cracks had been repaired by contractors. *Mr. JACKAMAN:* No failures and had spent nothing in repairs. Not known of any case in which concrete had flaked off from jar or shock or in which the reinforcement had rusted. Expansion cracks were occasionally set up, principally in panel-walls. Difficulties from expansion were entirely obviated by using brickwork panels—*i.e.*, a skeleton of reinforced concrete and walls of 9-in. brick. *Mr. WEBSTER:* Knew of a considerable number of failures, some due to defective design and others to faulty workmanship. Lack of provision for expansion often caused trouble. Durability of reinforced concrete in sea-water was an open question. *Mr. READ:* A few brown marks appeared in the water-tank at Newton-le-Willows, where the end of a bar had come near the surface of the concrete, otherwise reinforcement found not to be affected. Leakage caused by horizontal cracks attributed to expansion.

(Fire Risks.)—*Mr. HUNTER:* The fire-insurance premium would be less on a reinforced-concrete building than on an ordinary one.

Materials (Reinforcement.)—*Mr. HUNTER:* No steelwork was coated with cement wash; any rust was thoroughly scraped off. The connections were made by simply intertwining the rods. *Mr. WILSON:* Arranged that all loose scale should be scraped off, but the rods not polished. *Mr. LYNDE:* Had used ordinary round merchant bars. *Mr. JACKAMAN:* Always used steel specified by Messrs. Mouchel. *Mr. WEBSTER:* The use of ordinary mild steel should be continued. No predilection for any form of bar. Indented bars were used at the Stadium, but ordinary bars would have done as well. In square bar there was more area for the weight, and it was not necessarily easier to pack the concrete round a circular bar.

Tests and General Results (Loading Tests).—*Mr. SQUIRE:* Applied test-loads, 50 per cent. above working load to selected bays. *Mr. HUNTER:* Safe to test any properly-designed reinforced-concrete structure with double working load two months after moulds struck. In the transit-sheds selected portions of floor loaded with 3 tons pig-iron to sq. yd. *Mr. WILSON:* The test-load usually 50 per cent. above working load. Deflection $\frac{1}{800}$ of the span, with no permanent set, allowed. Concrete should be at least six weeks old before working load applied, and rather older before test-load applied. A truss bridge of reinforced concrete at Purfleet, with span of about 60 ft., showed no appreciable deflection under test-load. *Mr. LYNDE:* Used a test-load 50 per cent. over the working load and applied at eight weeks. Deflection allowed $\frac{1}{600}$ of the span. Only small percentage of total area of floor tested. Total deflection in some beams of 24-ft. span, tested at Bristol with load of 75½ tons, was $\frac{1}{4340}$ of span. *Mr. LYNDE:* Prepared to carry the working load on his work at five weeks. *Mr. JACKAMAN:* Usual test-load 50 per cent. above working load, which might be applied in six weeks, and test-load might be applied in six weeks in summer. *Mr. WEBSTER:* Used test-load rather in excess of the working load. Did not consider tests necessary; a bridge might carry test-load and perhaps another ton would smash it. *Mr. LYSTER:* Employed test-load 50 per cent. above working load with satisfactory results in every varying type of structure. Also usual tests on the steel and cement. *Mr. READ:* Arched roof at the Public Baths at Hammersmith showed no deflection under test-load.

(Stresses Allowed for Steel.)—*Mr. WEBSTER:* Stresses allowed on steel should not be higher than those allowed in ordinary steel structure. *Mr. READ:* Reinforcement of water-tank at Newton-le-Willows designed for stress of 7½ tons in.

(Thickness of Concrete Cover.)—*Mr. JACKAMAN:* Allowed thickness of 1½-in. concrete over all reinforcement in structures under water. *Mr. WEBSTER:* Concrete covering over the steel should be from about 1½ in. to 2 in. for work in water. *Mr. READ:* In the case of the water-tank concrete cover over the main rods was 1½ in. thick, and over small rods in shell of the tank at least 1 in. In a test-block exposed to weather, a thickness of 1 in. concrete had afforded perfect protection to steel bars for four years.

(Resistance to Fire and Heat.)—*Mr. WEBSTER:* Reinforced concrete was fire-resisting, not fireproof. The thicker the concrete over the reinforcement the greater resistance to fire; the protection, however, would crack off. *Mr. READ:* Example at Bermondsey where heat from furnace flue transmitted through a thickness of 5 ft. 6 in. concrete and brickwork. Burnt away tops of pair of piles without damaging the concrete.

"MEMORANDUM G" is a full report of the evidence and information given on special points of the enquiry, to which is appended some addenda of information upon works carried out and tests made by some of the engineers who gave evidence.

SPECIAL REPORTS.

In "MEMORANDUM H" are included the reports on various works executed. The structures referred to are as follows: Jetty Head at Thames Haven; Reservoir at Newton-le-Willows; Swimming-School Bridge at Steyr, Austria-Hungary; Pile Foundations for the Works of the Vienna-Danube Sand-Dredging Co., Austria-Hungary; Wharfing at Chantenay, Port of Nantes, France; Two Reservoirs at Châtillon-sous-Bagneux, France; Bridge near Mechanicville, N.Y., U.S.A.; High-level Reservoir for the Pyrmont Waterworks, Germany; Three-hinged Arch Bridge in Reinforced Concrete over the Prinz-Regenten-Strasse at Wilmersdorf, Germany; Water Towers at Piombino, Italy; Bridge across the River Bornida, near Millesimo, Italy; Viaducts at Merxem, near Antwerp, Belgium. Diagrams showing the general nature of the construction and arrangement of reinforcement should have been included.

We shall probably deal with these reports at a later date.

BIBLIOGRAPHY.

Finally, with regard to the "Bibliography" in the memoranda on experimental data, a list of references is given to the original publications in most cases, but apart from these there is no bibliography, strictly speaking—there is merely a kind of classified index to papers and abstracts referring to reinforced concrete which have appeared in recent volumes of the "Minutes of Proceedings Inst.C.E." As these are by no means exhaustive of the subject, a list of authoritative books, articles and papers on reinforced concrete would have been welcome. It rather suggests that the institution is attempting to leave text-books and journals, such as ours, severely alone, but as these contain much of the most important information, any attempt to remain aloof for fear of their "contaminating" influence would be ridiculous and reprehensible.

FUTURE WORK.

We hope, when the next interim report appears, to be able to notice in the proceedings that the Committee has got down to closer grips with the subject and has not disdained any sources of information.

The first thing to do is to bring our legislative summary of 1908 up to date. We are now in 1910. Then the examples of specifications should be amplified. The experimental data should be materially extended and analysed in an abbreviated tabular form, and, lastly, the bibliography completed. A supplement to the interim report embodying these points should be taken in hand before any new report is attempted.

NOTE.—For Appendix see next page.

Appendix:—Analysis of Certain Specialist Specifications for Work in Reinforced Concrete.

Subject.	British Reinforced Concrete Engineering Co., Ltd.	Trussed Concrete Steel Co., Ltd. (Kahn System).	British Concrete-Steel Co.	L. G. Mouchel & Partners (Hennebique System).	Considère Construction, Co., Ltd.	Expanded Metal Co., Ltd.	Edmond Coignet, Ltd.
CEMENT	British Portland, manufactured by firm approved to satisfy conditions as specified. Specific gravity not less than 3·15 when fresh, or 3·08 when aerated to 6° maximum rise in temperature. Initial set not more than 2 hrs.; final set, 7 to 10 hrs. Maximum residue 12% on a sieve of 32,000 meshes/in.^{2} Briquettes 1 in.^{2} in section neat cement made with about 20% water to withstand at least 8 days, 450 lb./in.^{2}; 15 days, 500 lb./in.^{2}; 29 days 540 lb./in.^{2} 1 cement to 3 standard sand mixed with about 10% water must stand in 8 days, 150 lb./in.^{2}; in 15 days, 200 lb./in.^{2}; in 29 days, 250 lb./in^2. Cement independently tested. For storage of cement proper shed. Cement to be aerated or seasoned before leaving manufacturers. Le Chatelier test: Cement to show as max. expansion of 6 mm. after 24 hrs. aeration, 3 mm. after 7 days aeration.	Production of Portland cement defined—must result from calcination to incipient fusion of intimate mixture of properly proportioned argillaceous and calcareous materials. Must be delivered in suitable bags with name of manufacturer plainly marked thereon. Rules as to storage, inspection, etc. Specific gravity, thoroughly dried at 100° C., not less than 3·10. Initial set not less than 40 mins., hard or final set in 2 to 10 hrs. All cement to pass a No. 76 sieve. Maximum residue on No. 180, 7%, on No. 240, 22%. Briquettes 1 in.^{2} in section to withstand: 24 hrs., 150 lb.; 7 days, 450 lb.; 28 days, 650 lb. 1 cement to 3 standard sand: 7 days, 160 lb.; 28 days, 250 lb. Rules as to constancy of volume, allowable amount of sulphuric acid and magnesia.	Best Portland, manufactured in Britain, to comply in all respects with British Standard Specification, dated June, 1907. To be superior in tensile strength and fineness of grinding. Briquettes neat cement shall bear, on average, 7 days after mixing, not less than 600 lb./in.^{2} Maximum residue on sieve of 32,400 meshes/in.^{2}, 9%. Maker's name and full address on every bag.	Cement only from manufacturers of good repute and conform as to preparation, quality, taking and preparation of samples for testing and chemical analysis, and chemical composition with British Standard Specification, with such modifications as herein contained. No cement containing added gypsum or other adulterant to be used without permission. Special soundness tests for use in sea or river water. Maximum residue. Sifted for a period of 15 mins. on a sieve 32,400 meshes/in.^{2} 15%. Initial set 50 mins. to 90 mins., final set 5 to 7 hrs. Set to be determined by resting point of lead pencil on pat. Rules as to storage of cement and protection against weather.	Portland, from an approved manufacturer and in accordance with British Standard Specification and subject to the tests therein provided.	Portland, to comply with requirements of British Standard Specification (revised June, 1907).	Slow-setting artificial Portland cement. Each consignment to be tested before use. British Standard Specification for cement may be used as a guide.
SAND	To be sharp, clean and gritty, free from ligneous, organic, earthy, or other impurities. Sand must be washed if necessary.	To be clean, coarse and sharp, with grains of various sizes, and contain smallest possible percentage of voids. Sand having over 5 per cent. of loam prohibited.	To be gritty, clean, and coarse, free from clay, chalk, lime, and earthy matter; or fine stuff from crusher may be used.	To be gritty, free from clay, chalk, lime, earthy, vegetable and organic matter and other impurities; to be mixture of coarse and fine grains from ¼-in. gauge downwards.	*Nil*	To be clean, sharp, gritty, consisting of mixed or graded sized grains from ¼ in. downwards, with coarse grains predominating.	To be coarse, gritty, river sand; should not contain any clay, chalk, lime or earth.

Subject.	British Reinforced Concrete Engineering Co., Ltd.	Trussed Concrete Steel Co., Ltd. (Kahn System).	British Concrete-Steel Co.	L. G. Mouchel & Partners (Hennebique System).	Considère Construction Co., Ltd.	Expanded Metal Co., Ltd.	Edmond Coignet, Ltd.
AGGREGATES (Gravel or Broken Stone)	Stone and gravel to be clean and of nature of cubes, not of flakes, of mixed sizes between ⅛ in. and ¾ in., free from sand and all soft pieces. Aggregate must be washed if necessary.	To be broken stone or gravel; stone should be hard, close-grained, and crushed to pass 1-in. diam. ring. Gravel to be free from dirt, ranging in size from pea to 1 in. All materials rejected to be immediately removed from vicinity.	To be of good, hard, clean stone or gravel, broken to pass ¾-in. mesh sieve, the fine stuff to be screened out by ⅛-in. screen. Therefore will consist of all sizes from ⅛ in. to ¾ in.; aggregates of one uniform size must be avoided.	Clean gravel, shingle or broken stone of any hard and durable nature permissible. Gravel to be exclusively hard and durable stone, free from sand, earth, clay, and other impurities. Stones to be of assorted sizes, not less than ⅛-in. gauge, nor more than ¾-in. gauge. Sandy gravel shall be screened to remove sand, which latter, if suitable, may be afterwards mixed with gravel in true proportions. Broken stone to be hard, close-grained, and durable rock, clean and free from refuse and foreign substances of assorted sizes, not less than ⅛-in. nor more than ¾-in. gauge.	To contain stones not greater than will pass ¾-in. mesh screen and varying down to ¼-in. mesh. Stones less than ¼ in. may go in with sand. All aggregates must be perfectly clean and free from all loam and other injurious matter.	To be clean, sharp, broken flint, gravel or hard and durable broken stone. For steelwork encasing, flooring, and similar work, if above not readily obtainable, hard broken brick or hard furnace clinker or mixture of both, free from combustible materials, old mortar ashes, and dust can be used. Cinders and coke breeze not recommended for reinforced concrete work. Aggregate to be of various sizes between ¾ in. and ⅛ in. in case of mixtures of 1 cement to 4 or 5 aggregate. In mixtures of 1 cement to 6 aggregate, sizes may vary from 1 in. to ⅛ in. Fine stuff, below ⅛ in., may be used in place of sand.	Gravel to be of various sizes, averaging between ¼ in. and ¾ in. Important not to use gravel all of one size. Broken stone, granite chippings, broken brick, or broken furnace slag may be used. Materials to be free from acids or sulphur. Furnace clinker, if of hard, vitrified nature, containing no ashes, unburnt coke or coke breeze may be used.
CONCRETE	Unless otherwise stated concrete to be composed as follows: Aggregate, 27 cu. ft. Clean river sand, 13½ cu. ft. Cement, 6½ cwts. Above proportions may be altered. Concrete to be thoroughly mixed in small batches, preferably in a machine, to a slightly wet consistency with clean water. Proper grading, mixing and consolidating must produce concrete to stand crushing test of not less than 3,000 lb./in.² (at one month	All concrete for slabs, beams and columns to be proportioned 1 cement, 1½ sand, 2½ broken stone or gravel. Concrete may be machine mixed, using either "batch" or continuous mixer of approved design. Plenty of clean water should be used, so that resultant may be known as a wet mixture. All materials should be first thoroughly mixed dry, after which proper amount of water added; mixing should continue until concrete is uniform.	Concrete shall be composed 1 cement, 5 aggregate and 1½ sand. Relative proportions of sand and gravel in the aggregate shall be ascertained frequently as work proceeds, so as to give densest concrete. Exact proportions of sand will depend upon interstices in aggregate, which is to be well wetted before mixing with sand and cement. Mixing must be very thorough, and if by machine it shall be of "batch" type and not of continuous type.	Unless proportion of voids in aggregate is greater than 50%, concrete shall be mixed in following proportions: For columns, beams, floors and like, 1 bag cement (224 lb.), 4½ cu. ft. sand and 9 cu. ft. aggregate. In all cases where weight of concrete per bag differs from 224 lb., volume of sand and aggregate to be varied proportionately. Proportion of voids to be accurately determined from time to time, and if proportion exceeds 50% volume of sand	Concrete to be mixed in following proportions: For piles or columns—23 cu. ft. stones, 11½ cu. ft. sand, 7 cwt. cement, making a volume of 1 cu. yd. concrete. For floors and beams—23 cu. ft. stones, 11½ cu. ft. sand, 5½ cwt. cement, making volume of 1 cu. yd. of concrete. Concrete to be mixed to a plasticity such that when mixed mass is struck with back of shovel a smooth surface without moisture can be obtained.	The following mixtures of concrete, all parts by measure, are recommended: For floors, walls, etc., up to 3½ in. thick—2¾ parts aggregate, 1¼ part sand, 1 part cement. For floors, walls, etc., thicker than 3½ in.—3¼ parts aggregate, 1¾ part sand, 1 part cement. For general concrete work, such as foundations and heavy work—4 parts aggregate, 2 parts sand, 1 part cement. For concrete to retain	Mixture generally used is: 3 parts cement, 5 river sand, 10 gravel, or other suitable material. This gives 12½ parts of concrete, loss in bulk being about 30%. May also be expressed as a 1-to-5 mixture. Always advisable to make small block of concrete in order to ascertain whether mixture is apparently homogeneous and sound. If cavities appear it may be necessary to increase proportion of sand and cement. A 1-to-4 mixture should be used

The Institution of Civil Engineers. Analysis of Certain Specialist Specifications for Work in Reinforced Concrete.—*Continued.*

Subject	British Reinforced Concrete Engineering Co., Ltd.	Trussed Concrete Steel Co., Ltd. (Kahn System).	British Concrete-Steel Co.	L. G. Mouchel & Partners (Hennebique System).	Considère Construction Co., Ltd.	Expanded Metal Co., Ltd.	Edmond Coignet, Ltd.
CONCRETE *continued*	after making (on 4-in. cubes.	Competent foreman must be in constant attendance at mixer to give approval of every batch which leaves machine.	If mixed by hand, sand and cement must be turned over on timber platform 3 times dry, aggregates then added and whole turned over again; water then added by means of rose and whole then turned over 4 times whilst wet. Water to be fresh, clean and wholly free from salt.	and weight of cement shall be increased, so that mortar shall never be poorer than quality obtained by mixing 224 lb. cement to 4½ cu. ft. sand for ordinary, or to 3¾ cu. ft. for work in tidal waters or for piles. Water added shall be sufficient to make plastic mixture, capable of being rammed into all parts of mould and between bars of reinforcement. Water to be increased in hot weather. Boxes of requisite size to be used for gauging so as to exercise control over proportions. Concrete shall be mixed in machines of approved design. Capacity of mixers to be such as to meet requirements, without at any time producing appreciable excess. All concrete shall be used when freshly mixed, especially in warm weather. In small works, hand-mixing may be resorted to. All hand-mixed concrete for ordinary work shall be made in the following proportions: 1 bag cement (224 lb.), 4 cu. ft. sand, and 8 cu. ft. aggregates. Water for mixing cement grout, mortar, and concrete to be clean.		liquid pressures — 3 parts aggregate, 2 parts sand, 1 part cement.	for walls of tanks and reservoirs, and for piles. Weight of concrete including reinforcement equals 156 lb./ft.^{3} Proper gauge boxes to be used. Mixing to be done by machinery, but if by hand materials should be thoroughly mixed together, both dry and wet. Enough water should be used to obtain proper setting. Concrete should be sufficiently plastic to thoroughly fill the mould, leaving no gaps. Concrete should not contain too much water, as this may occasion a drip of the cement. Concrete should not be exposed to sun and should be moistened for a few days after concreting operation has been finished to hasten setting. No concreting to be carried out in frosty weather. Work to be adequately protected from rain and frost. Concrete to be well rammed in order that framework may be entirely surrounded. When concreting operations are suspended, it is necessary to leave a rough facing to work to serve as a key for new material. Posts and beams must always be completed without any interruption.

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REINFORCEMENT	All rods, plates, bars or braces to be of mild steel, manufactured on open-hearth basic or acid Siemen's process, uniform in quality, and entirely free from defects. Ultimate tensile strength not less than 28 nor more than 32 tons/in.^{2} Elongation to be at least 20% in length of 8 in. Steel bars to be capable of being bent 180° round a bar of 1½ times their own diameter when cold without injury. All steel on delivery to be cleaned and stored in a dry place. All steel to be in its natural state, free from oily or greasy matter and loose scales. Bars to be bent cold. No heating or welding allowed except with special permission. All stirrups and hoops to accurately fit rods and bars to be bent to proper shape.	No reinforcing steel shall be considered that does not provide for shearing stresses as well as direct tension. These shear-resisting members must be inclined at an angle of 45° pointing up and towards the supports of the structure. Shear members shall be rigidly attached to main tension members. Sufficient steel to be placed that concrete shall be obliged to resist only direct compression and shearing stresses up to 50 lb./in.^{2} No steel shall have at any point less than 1 in. concrete covering. Steel bars not to be painted. In no case will steel of a higher elastic limit than 45,000 lb. be considered. Same shall have a tensile strength of from 60,000 to 70,000 lb. per sq. in., with elongation not less than 20% in 8 in. A bar should bend cold around its own diameter through an angle of 180° and close down upon itself without cracking.	The indented steel bars to be of best quality; tensile strength 38 to 42 tons/in.^{2}. Elastic limit not less than 50,000 lb. (22 tons)/in.^{2} Elongation not less than 15% on 8½ in. A bar shall be capable of being bent cold around another bar of 4 times its own dimension or diameter without fracture. Steel bars for reinforcing concrete will be cut to the required lengths, delivered to nearest railway station, and bundled; each bundle being labelled to show part of work for which intended. Contractor must straighten damaged bars and also bend such as may be required in the different parts of work. Larger bars must be heated before they are bent. Ample supply of soft iron wire is to be provided for lapping steel bars at joints and at points where they cross each other.	Steel to be in the form of round bars and strip, obtained from makers of good repute, and to be mild steel produced by the open hearth, basic or acid process. Neither Bessemer steel nor high carbon-steel to be employed. To have ultimate tensile strength from 28 tons to 32 tons/in.^{2}. Elongation not less than 20% in 8 in. To be capable of being bent cold round a bar of 1½ times its own diameter, without fracture. Each consignment of steel to be tested. Special regulations for taking samples. Steel to be clean. Any loose rust to be removed before use. No weld to be made in any bar without sanction. All bars to be bent cold. Special attention to be paid to splitting and fish-tailing all bar ends. Bars ½ in. and smaller to be merely flattened at ends. Number, size, form and position of all steel bars, etc., to be in accordance with working drawings. Longitudinal bars in columns, struts, and piles to be straight, and fixed parallel to each other and sides of moulds. Ties taut and properly braced. Precautions as to horizontal and bent bars, etc. No bar to be placed less than 1 in. from inside of mould.	Steel must be of British manufacture and have tensile strength not less than 28 tons or more than 32 tons/in.^{2}, and show contraction of area at fracture of 50% and 40% respectively, and appearance of fracture not to show more than 5% and 10% granular surface respectively.	Table given, based on mixture of concrete not less than 1 : 2 : 4 by volume. Working stress not exceeding 16,000 lb./in.^{2} in tension in the expanded steel, and 500 lb./in.^{2} extreme surface compression in the concrete. Ratio of the moduli of elasticity of steel and concrete taken as 15.	For framework plain round bars of mild steel to be used with tensile strength of about 58,000 lb./in.^{2} and elongation 22% in 8 in. Average working strain generally taken at 16,000 lb./in.^{2} Bars not in any case to be covered with coat of paint or any other material. In case of very long bars it may be necessary to employ welds, but in no case is welding to be resorted to without permission, and exact position of welds must be fixed. Bars meant to form anchorage in concrete, or subjected to direct strain, must have ends fish-tailed. Annealed wire used for binding together various bars of framework at intersection should be about $\frac{1}{16}$ in. dia. Binding to be done as tightly as possible and cutting pliers used. Special precautions laid down as to suspension of framework in beams by upper bar, etc. Bars must be kept to exact position as to spacing shown on drawings. Absolutely indispensable that mild steel be used.

THE WESLEYAN HALL, WESTMINSTER.

REINFORCED CONCRETE CONSTRUCTION.

The use of reinforced concrete in so important a building as the Wesleyan Hall marks another step in the development of the material for building purposes in Great Britain.—ED.

REINFORCED concrete is being extensively employed in the new Wesleyan Hall now being erected on the site of the old Aquarium in Westminster from the designs of Messrs. Lanchester & Rickards, and splendid opportunities were offered for scientific construction in the galleries and dome to the large hall.

There are practically three principal floors in the main part of the building, exclusive of the galleries, these being the basement, where two large tea rooms are provided; the ground floor, where the library and small hall are the principal apartments; and the first floor, on which is situated the large conference hall. There are several mezzanine floors introduced where the height required by the principal apartments would have been excessive for the smaller rooms, and the rear portion of the building is occupied by offices.

There is one floor below the pavement level, and this is 16 ft. in height, while the total height of the building from the pavement to the springing of the large central dome is about 92 ft.

Foundations.—The foundations are constructed of plain and reinforced concrete, the soil being a good dry bed of sand and gravel, with practically a uniform carrying capacity, which was taken at 2 tons per sq. ft. The system employed was practically that of a solid concrete platform over the whole site, with a thickness varying from 1 ft. 3 in. to 7 ft. 6 in. The underside of the concrete was kept at one level—viz., 7 ft. 6 in. below the basement floor line, and the additional thickness was applied as necessary on the upper side. The effect of this system was that certain space occurs where the concrete was the minimum thickness, and this was useful for drains, ducts, cables, etc. Reinforcement consisting of ½-in., ¾-in., and 1-in. trussed bars was utilised in certain positions on account of extra loading or reduction in thickness of concrete, while a form of grillage foundation was adopted under the large stancheons which carry the weight of the large dome at four different points. These stancheons are of a steel lattice type, and the weight is brought down to the foundation by a pair of stancheons in each case, and the bases are carried by eight 10-in. by 5-in. rolled steel joists, which in turn are carried by seven 14-in. by 6-in. joists, each about 16 ft. long. The whole of this foundation is then enveloped in cement concrete.

Floor over Tea Rooms.—The work to the large tea rooms in the basement affords an interesting example of the possibilities of reinforced concrete, and, in fact, it is improbable that any other material could have been successfully used owing to the effect desired. These tea rooms are approximately each 65 ft. long by 41 ft. wide, and the ceilings are constructed as reinforced concrete domes, the drawings for which can be seen in *Figs.* 4 and 5. It will be noticed

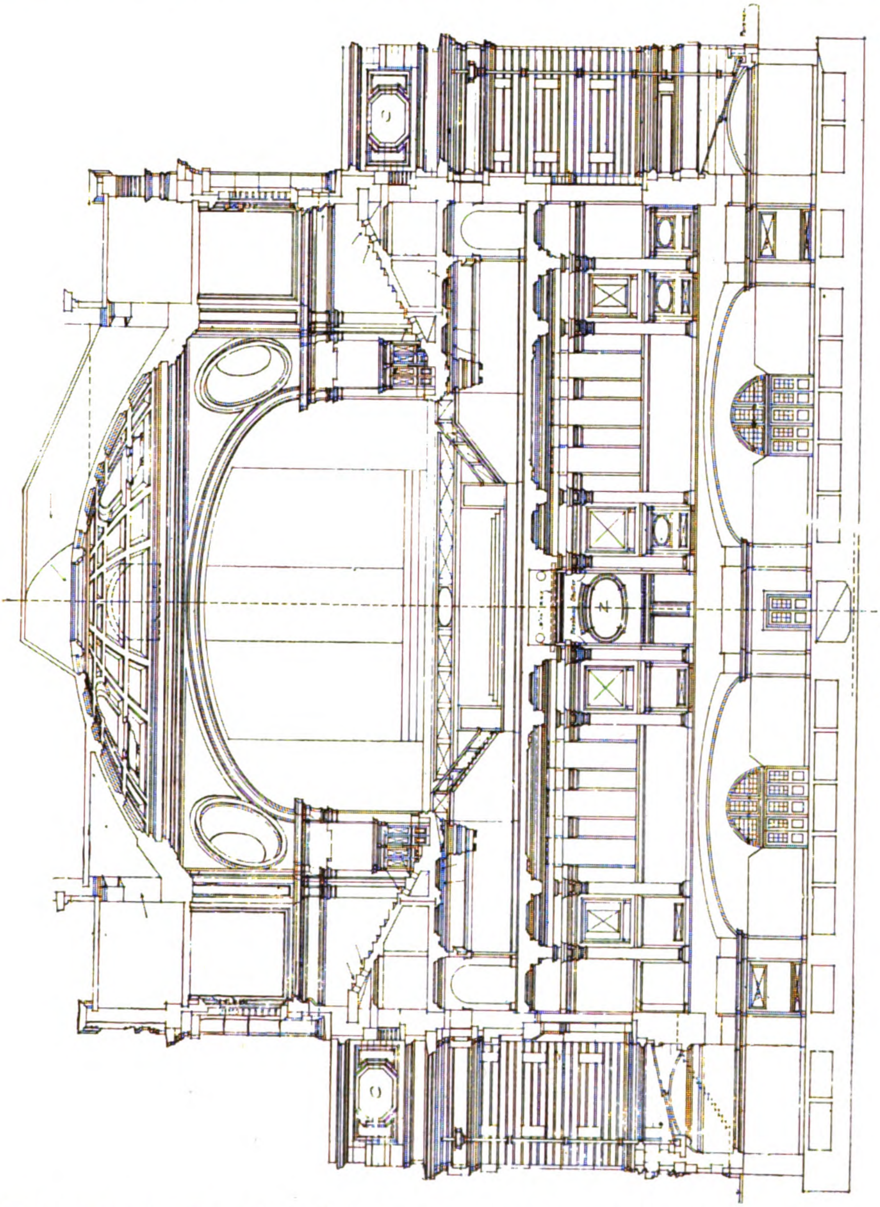


Fig. 1. Cross section.
WESLEYAN HALL, WESTMINSTER.

on reference to the key plan that the ceiling and floor above each room are carried by six piers, which are connected by curved reinforced concrete ribs, each 3 ft. 3 in. wide, and reinforced with four 1¾-in. Kahn bars at top and bottom. The central portion of the room, which measures about 42 ft. by 29 ft., is covered with an elliptical dome, which has a rise of about 6 ft. only, and as this springs from a rectangular plan it will be readily understood that great care was necessary in carrying out the work to get a true shape, particularly in the case of the pendentives. The thickness of the concrete was 9 in., and the reinforcement consisted of ¾-in. Kahn bars at 12-in. centres. The horizontal floor above the dome is formed with 5 in. of concrete reinforced with ½-in. bars at 12-in. centres, and this is attached to the ceiling at the crown of the latter only, thus leaving an open spandrel space between the two. The piers carrying this work (shown in *Fig.* 10) are 4 ft. square, constructed of concrete reinforced with eight 1-in. Kahn bars and 1-in. and ¼-in. hooping at 3-in. pitch, the bars being extended

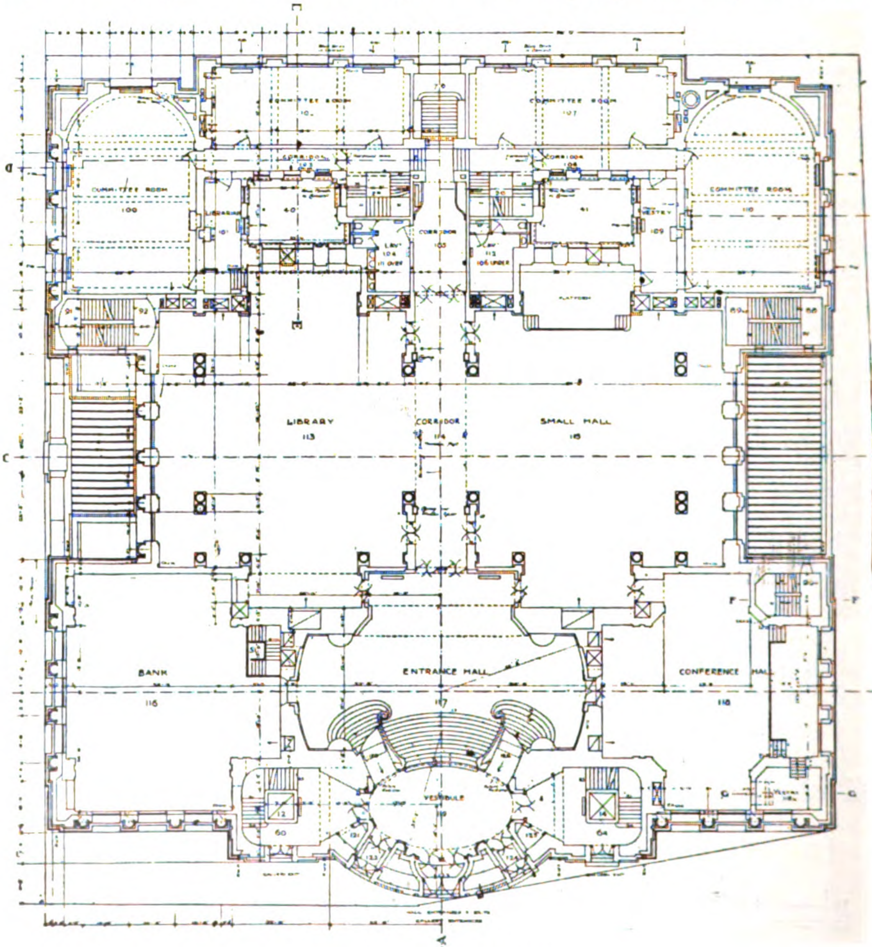
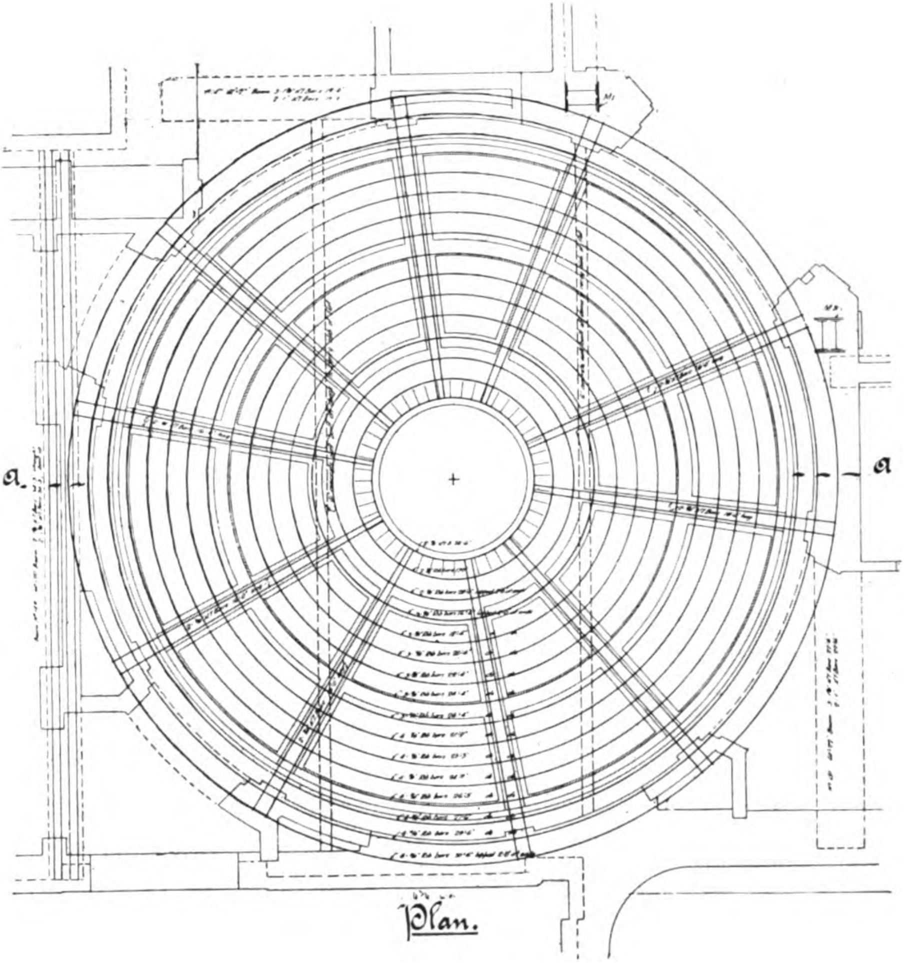
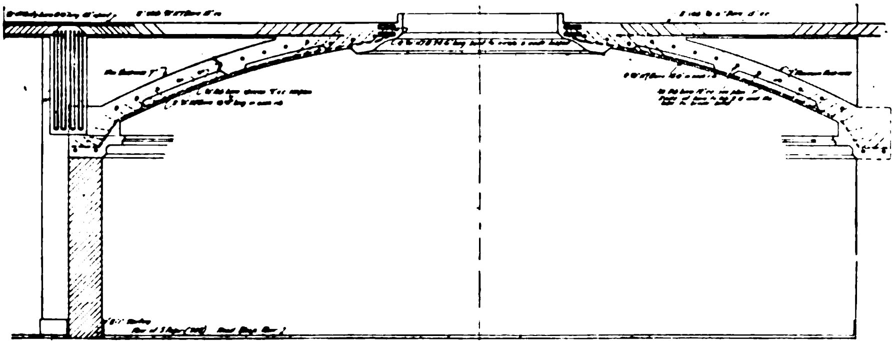


Fig. 2. Ground Plan.
WESLEYAN HALL, WESTMINSTER.



Plan.



Section A.A.

Fig. 3. Dome over Foyer.
Wesleyan Hall, Westminster

upward for a short distance into the lower part of the ribs, thus forming one complete construction.

Columns.—The floor of the main conference hall is carried by several reinforced columns, which are constructed in the library and small hall on the ground floor, and these are interesting on account of the manner in which they were formed. The height of these columns is about 28 ft. while the diameter is 2 ft. and the reinforcement consists of eight 1-in. ribbed bars with $\frac{3}{16}$-in. hooping at 6-in. pitch, the bars being kept back from the face of the concrete 1½ in. An

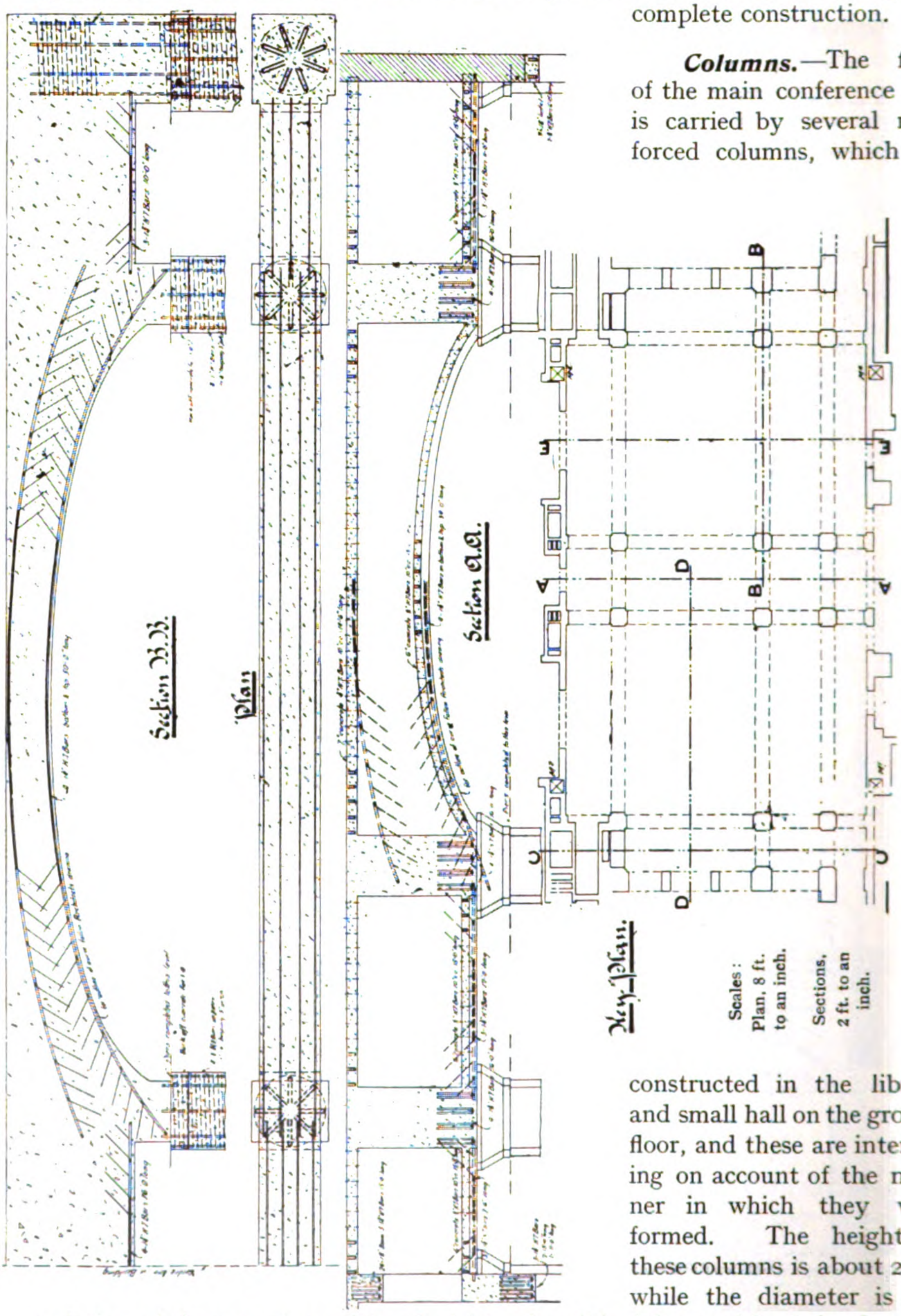


Fig. 4. Details of Ceiling and Floor over Tea Room.
WESLEYAN HALL, WESTMINSTER.

entasis was required on these columns, and in order to avoid the necessity of a large amount of "making out" by the plasterer when finishing the column,

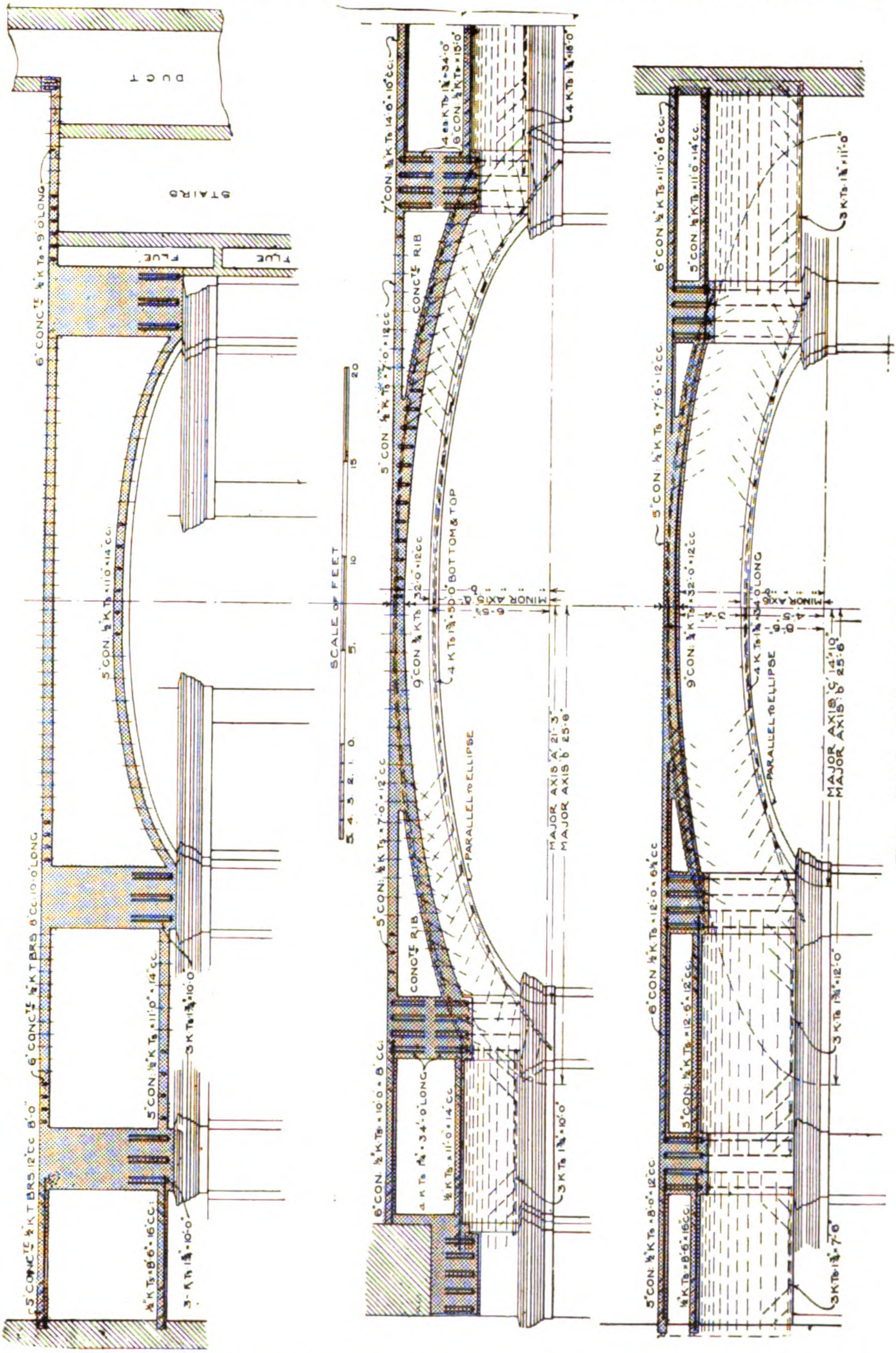

DUCT
STAIRS
FLUE
FLUE
6" CONC^{TE} ½" K Ts • 9' 0" LONG
5" CON ½" K Ts • 11' 0" • 14" cc
6" CONC^{TE} ½" K T BRS 8" cc • 10' 0" LONG
6" CONC^{TE} ½" K T BRS 12" cc 8' 0"
5" CONC^{TE} ½" K T BRS
5" CON ½" K Ts • 11' 0" • 14" cc
3 K Ts 1⅛" • 10' 0"
½" K Ts • 8' 6" • 16" cc
3 - K Ts 1⅛" • 10' 0"
SCALE OF FEET
5 4 3 2 1 0 5 10 15 20
7" CON ½" K Ts • 14' 6" • 10" cc
4 sq K Ts 1¼" • 34' 0"
6" CON ½" K Ts • 15' 0"
4 K Ts 1⅛" • 16' 0"
CONC^{TE} RIB
5" CON ½" K Ts • 7' 0" • 12" cc
9" CON ¾" K Ts • 32' 0" • 12" cc
4 K Ts 1⅛" • 50' 0" BOTTOM & TOP
MINOR AXIS
PARALLEL TO ELLIPSE
MAJOR AXIS 'A' 21' 3"
MAJOR AXIS 'B' 25' 6"
5" CON ½" K Ts • 7' 0" • 12" cc
CONC^{TE} RIB
6" CON ½" K Ts • 10' 0" • 8" cc
4 K Ts 1⅛" • 34' 0" LONG
½" K Ts • 11' 0" • 14" cc
3 K Ts 1⅛" • 10' 0"
6" CON ½" K Ts • 11' 0" • 8" cc
5" CON ½" K Ts • 11' 0" • 14" cc
3 K Ts 1⅛" • 11' 0"
5" CON ½" K Ts • 7' 6" • 12" cc
9" CON ¾" K Ts • 32' 0" • 12" cc
4 K Ts 1⅛" • 34' 0" LONG
MINOR AXIS
PARALLEL TO ELLIPSE
MAJOR AXIS 'C' 14' 10"
MAJOR AXIS 'D' 25' 6"
6" CON ½" K Ts • 12' 0" • 6½" cc
5" CON ½" K Ts • 12' 6" • 12" cc
3 K Ts 1⅛" • 12' 0"
6" CON ½" K Ts • 8' 0" • 12" cc
½" K Ts • 8' 6" • 16" cc
5" CON ½" K Ts
3 K Ts 1⅛" • 7' 6"

Fig. 5. Details of Ceiling over Tea Rooms.
WESLEYAN HALL, WESTMINSTER.

this entasis was actually formed in concrete, and thus a surface was formed on which the plasterer could work direct and use a finishing coat of a uniform thick-

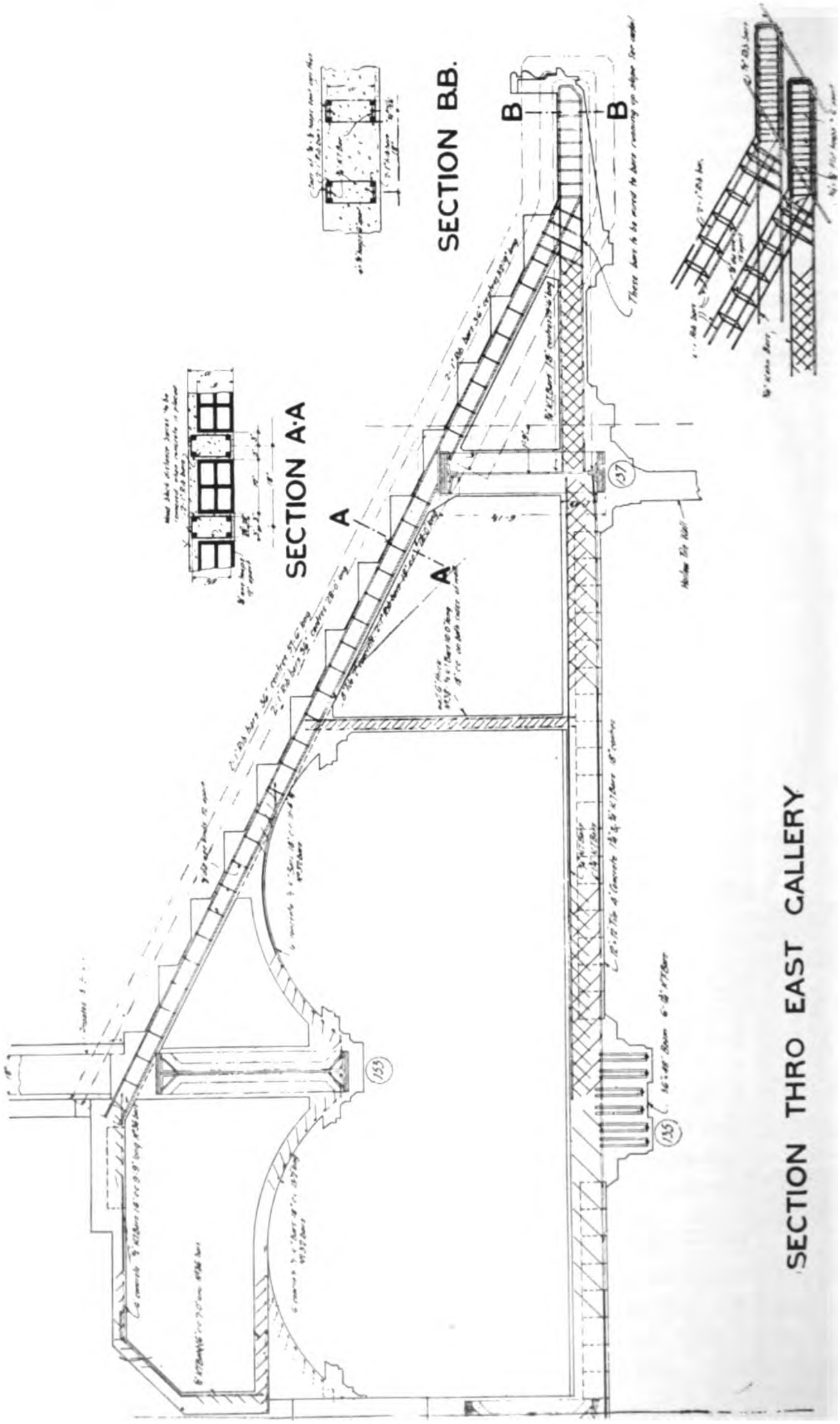


Fig. 6. Details of Gallery Construction.
Wesleyan Hall, Westminster.

ness. Some careful setting out and very accurate shuttering was necessary to obtain a true line, as the concrete had to be cast vertically for one-third the height, and above that level it diminished slightly in diameter to the top of the shaft, and this diminution had to take the form of a slight curve. The boxings were made in sections about 4 ft. high, and consisted of narrow battens placed vertically, which could easily be bent to the required curve, and these were secured to horizontal pieces that were set out with their outer edges plumb while the inner edges were formed to a curve coinciding with the diameter of the column at each particular point, these horizontal pieces occurring at intervals of 2 ft. throughout the

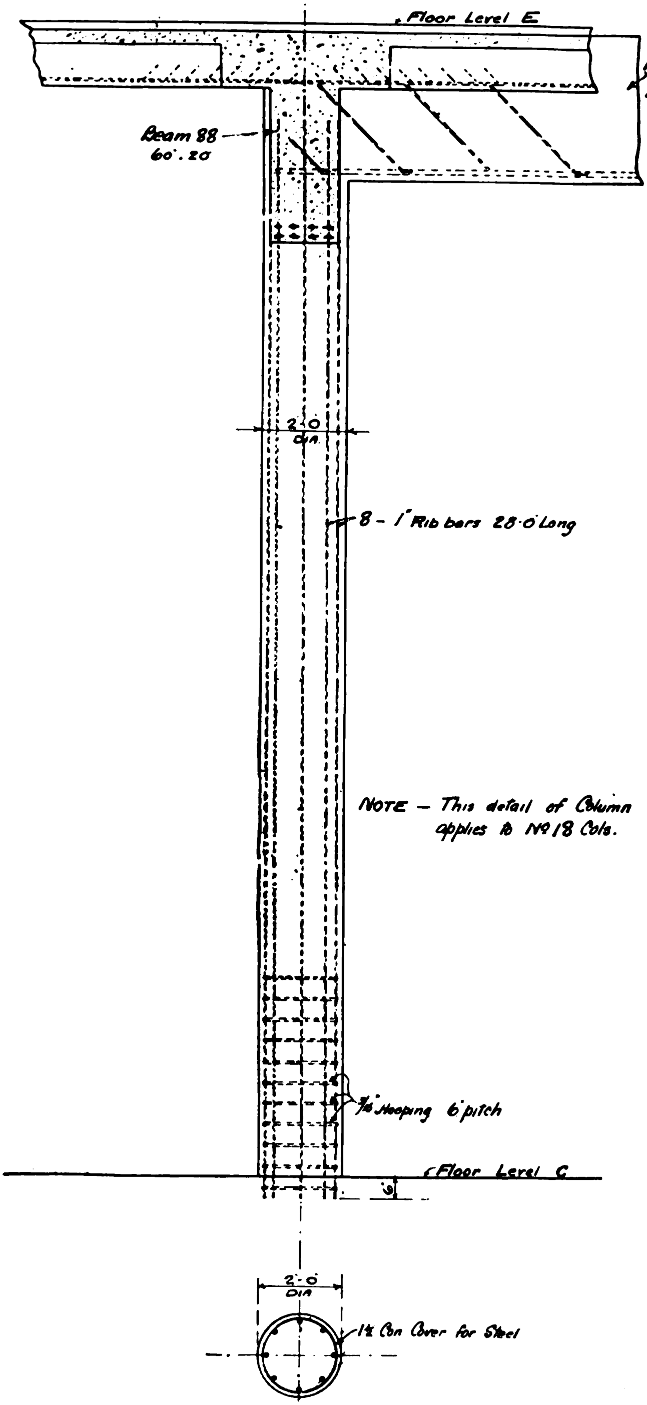


Fig. 7. **Detail of Columns supporting Main Hall**
WESLEYAN HALL, WESTMINSTER.

height. The result is extremely successful, and the surface and line obtained is such that it would be possible to finish the column with cement ¼ in. thick. The rough outline of the cap and entablature are also formed in the concrete. The position of these columns can be seen on the plan of the ground floor (*Fig.* 2), and the floor of the main hall above which they carry was calculated to carry a live load of 200 lb. per sq. ft. The photograph (*Fig.* 9) gives an excellent idea of two of these columns as actually carried out.

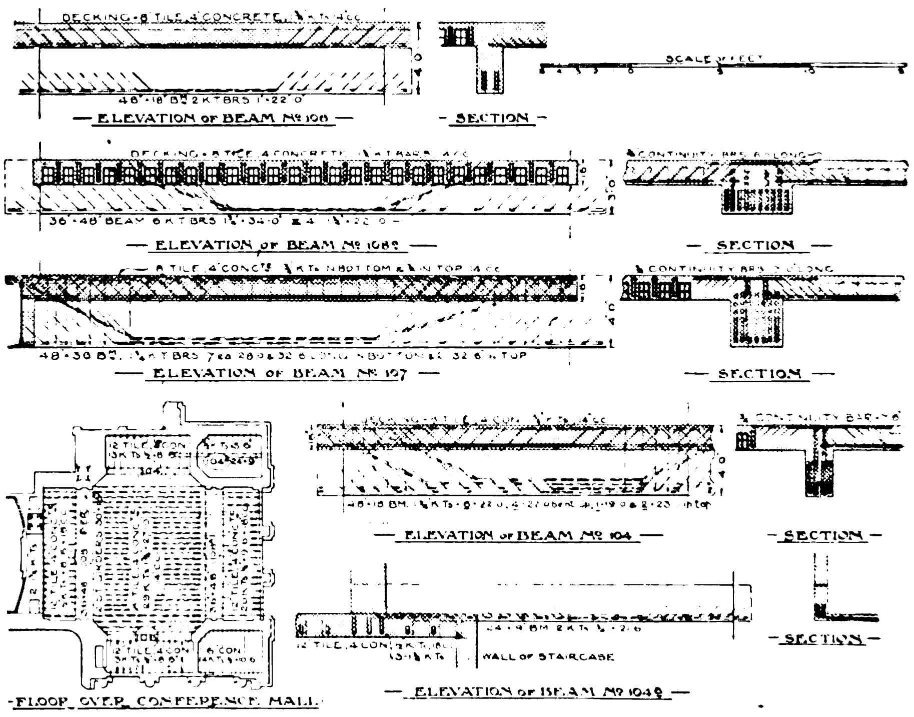


Fig. 8. Details of Floor Construction.

Wesleyan Hall, Westminster.

Floors.—The construction of the floors throughout is that of reinforced concrete, and, with the exception of those to the offices in the rear, tiles are introduced to lighten the weight of the floor itself, and assist in preventing the conduction of sound. Some details of this work are illustrated in ***Fig.* 8,** and it will be seen that the system consists in placing 8-in. or 12-in. hollow tiles on edge in the lower surface of the floor with a space of 6 in. between same, this space being occupied by the concrete and Kahn bars, which were used as reinforcement, while the whole of the upper surface of the tiles was covered with 4 in. of concrete. The hollow tiles were grooved on all faces to give a good key both for the concrete at the sides and the ceiling plaster, which is applied directly to them on the under side. The floors to the offices at the rear were constructed of 7 in. of concrete reinforced with ¾-in. trussed bars at 10-in. centres.

The loads calculated for the different rooms vary from 200 lb. per sq. ft. in the main hall to 100 lb. per sq. ft. in the committee rooms, offices, and smaller apartments, while 150 lb. per sq. ft. was allowed for the corridors and cloak rooms, and 125 lb. per sq. ft. for the galleries, library, and small hall.

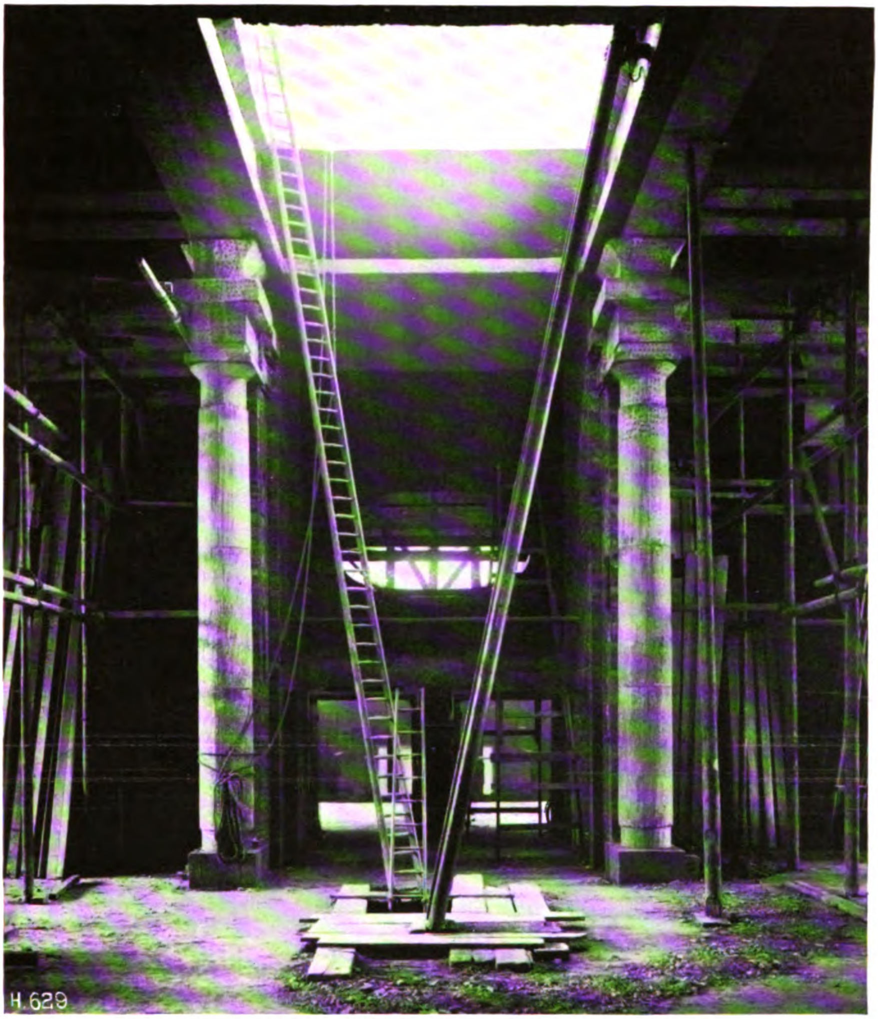


Fig. 9. Reinforced Concrete Columns.
WESLEYAN HALL, WESTMINSTER.

Galleries.—The galleries in the large hall provide some very interesting construction, and that situated on the east side is illustrated in *Fig.* 6. These galleries run round on three sides of the hall, and they are formed in reinforced concrete, although steel plate girders assist in some cases in carrying the weight, as will be seen by a study of the drawings. The front portion of the gallery is cantilevered out for a distance of about 14 ft. 6 in., and it is this part of the work which required the most careful design and execution. The sloping portion, which actually carries the tiers for seating accommodation, makes an angle of about 52° with the horizontal, and this is carried through in one slope about 38 ft. long, with a minimum thickness of 10 in. Hollow tiles were again employed to effect a lighter construction, these being 12 in. by 8 in., and spaced 6 in. apart in the clear. The reinforcement consisted of 1-in. rib bars, four being placed in the concrete between each tile, two in the upper and two in the lower surface, and ⅛-in. wire hoops were placed at 12-in. centres around all four bars. The tiles were covered with a minimum thickness of 2 in. of concrete, making a total thickness of 10 in. The bars were made as continuous as possible, and many of the upper bars were carried right out to the end of the projecting portion and then turned round and continued up the slope on the under surface. The horizontal portion below the slope was reinforced with ¾-in. Kahn bars at 18-in. centres, and these bars were carried out to the end of the slope between the rib bars, which were previously mentioned, and the whole wired together with ¾-in. by ⅛-in. flat hooping at 6-in. centres. Two ½-in. rib bars were also placed transversely in the cantilevered portion to form a tie, as will be seen in the detail drawing of this work already mentioned (*Fig.* 8). The floor under the gallery is constructed of 12-in. by 12-in. tiles covered with 4 in. of concrete and reinforced with two trussed bars, 1¾ in. and ¾ in. respectively, at 18-in. centres. A large concrete beam carries the greater part of the weight from the floor, the size being 36 in. by 48 in., and the reinforcement consisting of six 1¾-in. trussed bars.

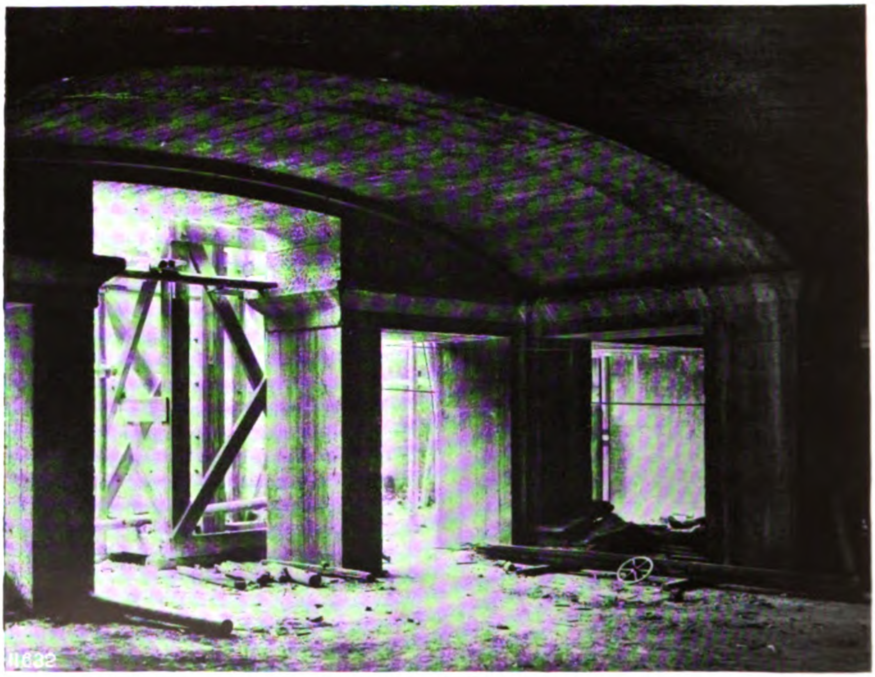


Fig. 10. View in Tea Room.
WESLEYAN HALL, WESTMINSTER.

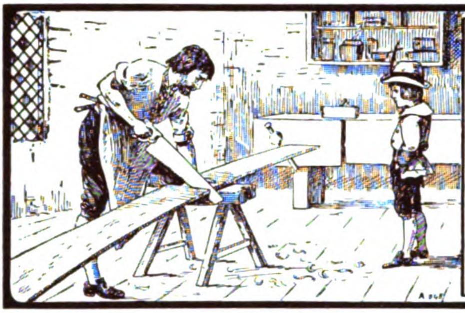
Domes.—These occur both over the main hall and over the foyers in the front portion of the building, and one of the latter is illustrated in *Fig* 3. The diameter is about 34 ft., and the rise about 4 ft. 6 in. only. The central portion, 7 ft. in diameter, is left open for lighting purposes. The dome is coffered on the under side, and the panels are all formed in the concrete, ten ribs occurring which radiate from the centre, these being reinforced with two ¾-in. Kahn bars. The remainder of the reinforcement is provided by ¾-in. rib bars, which run right round the dome at 12-in. centres, the minimum thickness of concrete being 7 in. All bars that could not be continuous, on account of the excessive length required, were lapped 2 ft. at the ends with the adjoining bar. The flat which occurs above the dome is carried by two 6-in. concrete walls, which are built up from the top of the dome itself.

The large dome, which occurs in the centre of the building over the main hall, is one of the features of the building. The internal dome, which will be visible from the hall itself, will be built entirely in reinforced concrete, while the external dome, visible as part of the elevations of the building, will be constructed of a light steel framework erected over the concrete internal construction. This concrete dome has a diameter of 114 ft., and it is supported by four huge concrete girders having a span of 68 ft., each 18 ft. deep at the centre. The soffite of these girders follows the line of the elliptical ceilings over the galleries, and encloses the oriel windows which occur in the pendentives of the dome. They are carried right round the upper portion of the building, and supported on the eight main stanchions, which, as previously mentioned, are carried up in four pairs at the corners of the dome, and connected together before receiving the large concrete girders. The estimated weight on each pair of stanchions, including that coming from the large dome and galleries, is 1,100 tons, and this is taken down to the grillage foundation, as already described.

Concrete.—The proportions used in the concrete vary slightly according to its particular position in the work, but, generally speaking, a mixture of 1 part of cement, 2 parts of sand, and 4 parts of shingle was employed, and the whole of the shingle was well washed before being used. The mixing was entirely executed by hand, those responsible for the work considering that a more uniform concrete is obtained by hand mixing than by machine mixing. The mixture was laid very wet, and in forming the floors and similar work the whole of the concrete was wetted and well raked during the process of laying. The results are certainly excellent, and the finished concrete is very uniform in texture and extremely hard. Generally speaking, three weeks were allowed to elapse between the time of laying the concrete and striking the shuttering.

Stonework.—The whole of the elevations are built in Portland stone, the frontispiece to this issue illustrating the work during execution. Roman stone is being used internally to a great extent, one of its chief uses being in the very fine staircase situated in the front of the building which leads up to the main hall on the first floor. The remaining staircases are constructed in plain concrete well pinned into brick walls, and finished with granolithic.

The general contractors for this building are Messrs. Dove Bros., of Islington; the reinforced concrete work was designed and the reinforcement supplied by the Trussed Concrete Steel Co., Ltd., Caxton House, Westminster. The constructional steelwork was executed by Messrs. Dawnay & Sons, Ltd., and the Portland Cement supplied was of the J. B. White & Bros. brand.



THE CONSTRUCTION OF CONCRETE FENCE POSTS.

The use of reinforced concrete fence posts is making some headway even in this country, and several of the more enlightened chief engineers of railway companies have started to specify them freely, recognising their practicability and economy. Others, we trust, will soon follow suit.

In the meantime, we would again publish some particulars on the subject, as based on American practice.—ED.

Comparative Advantages of Concrete and Wooden Fence Posts.—As a material for the construction of fence posts, concrete has not only very few of the disadvantages and practically all of the advantages of wooden posts, but it is also superior to timber in some respects. In the first cost concrete posts may be more or less expensive than the best wooden posts, according to the locality. This depends upon the timber supply, the deposits of gravel and rock, and the skill exercised by the person making the concrete posts.

If manufactured as usual and cured for three months, concrete posts are as good as the best wooden posts of the same size. After three years' service wooden posts possess only from one-third to one-half of their original strength, whereas concrete grows stronger with age and needs no repairs, for neither weather nor fire injures it. Under ordinary circumstances, good concrete posts will last for ever; and even if a few, in the course of years, should be broken by unusual strains, it is cheaper to replace these than to replace an entire fence of decayed wooden posts with posts of material with the same lack of durability.

Concrete posts are attractive in appearance because of their uniformity of size and colour and, because of their durability, they effect a saving in giving greater life to the fencing material used, so that the permanent value of the property is increased.

Moulds for Line Posts.—Moulds for concrete line posts are made of both steel and wood, and are built for single posts or in " sets " or " gangs." In deciding the size of the top and bottom of the post, and consequently of the mould, one should take into consideration the nature of the ground in which the post will be set. A very loose soil requires a post with larger ends and wider sides or a greater length for deeper setting in the ground. A careful observation of the smallest wooden post found satisfactory will help in deciding the size of the concrete post.

Steel Moulds.—The purchaser will find many patented steel moulds on the market. It is advisable to buy a form simple in its general shape, for in such a mould the reinforcing can be placed more exactly where it belongs. Steel has some advantages over wood, since it is lighter, less cumbersome to handle, and gives the post a neater finish and any shape desired. Where the appearance is important, steel moulds are to be preferred to wooden. Neighbours often club together, when this is desirable, in order to buy steel moulds and so economise in this expense.

Wooden Moulds.—Wooden moulds good enough for ordinary demands are very easily made. White pine is the best wood for this purpose, but at the same time it is the most expensive. Cheaper kinds of lumber, which are easy to work with, may be used. Moulds made of 2-in. planks, dressed on both sides, form neater posts, but lighter lumber may be used, if the forms are well braced.

In imitation of the manner in which tree trunks grow, concrete posts are usually made tapering in size from butt to top. While this method may add a little to the appearance of the post and effect a slight saving in concrete, this saving is largely offset by the additional cost of the carpenter's work and of the lumber used in making the moulds. Theoretically, the tapering post has a better design than the one with straight sides, but for ordinary use one is as good as the other.

In making these moulds, dressed lumber, planed from the rough, should be used. The proper dimensions for rough timber are 1 or 2 in. thick and 4, 6, 8, 10, or 12 in. wide; for dressed lumber they are $\frac{7}{8}$ or $1\frac{5}{8}$ in. thick and $3\frac{5}{8}$, $5\frac{5}{8}$, $7\frac{1}{2}$, $9\frac{1}{2}$, or $11\frac{1}{2}$ in. wide.

Moulds for Square Posts.—Moulds for posts that are square or nearly square in cross section are simple and easy to make. They are built in three patterns: (1) For posts without taper; (2) for posts tapering on two sides; and (3) for posts tapering on all four sides.

In order to avoid a sharp, irregular edge, neater posts are made by fastening a narrow strip of canvas or leather on the inside of the sideboard at the bottom of the mould, so that when the mould is put together and the concrete post moulded the corner of the post will be rounded. A similar effect on the upper side of the post is produced by using a trowel or an "edger"—a special tool for rounding the corners of concrete walks or curbs. Clay plastered in the corner of the mould or wooden strips tacked to the sideboards will answer the same purpose. Such strips must, however, be as small as possible or else they will crowd out much concrete, and thus cause the reinforcement to be located too far within the post to obtain the best results. Ordinarily the reinforcement should be placed within three-fourths of an inch or 1 inch of the outside of the post.

For Posts without Taper. —The easiest and cheapest mould to make is the straight mould, or one for a post which does not taper. Such moulds are merely long boxes built with various schemes for making the moulding of the post a simple matter. On account of the amount of lumber saved and the ease with which these moulds are filled, straight moulds are generally made in "sets" or "gangs," by constructing several side by side with a continuous bottom and end pieces. *Fig.* 1 shows the plan of a "gang" mould for making six posts, each of which is 7 ft. long and 5 in. by 5 in. at both ends. On account of the rigid method of construction, all lumber used in this mould, with the exception of the 2-in. by 4-in. stringers, may be 1-in. dressed boards. The bottom is of "ship lap" cut to the dimensions indicated on the drawing and nailed tightly to the three stringers. The end pieces (E) are made up of one board each to which are nailed blocks (B) 1 in. in thickness and 5 in. square, placed so as to allow the side pieces (S) to slip between them. The end pieces are hinged to the bottom with strap hinges (H), in which the fixed pin is replaced by a loose pin or a nail. This arrangement allows the end piece to be removed at will. Shutter hinges or loose-pin door butts of heavy wrought iron may also be used as hinges. All the side pieces are alike and interchangeable.

The form is set up ready for use in this manner. The end pieces are placed in position by inserting the loose pin of the hinges. Lengthened wagon rods (W), with crank nuts (N) at one end, are dropped into the slots (K), and the sideboards are then placed in the grooves (G) between the blocks on the end pieces. All the pieces are then drawn together by tightening the crank nuts (N). The slots for these rods should be faced with an iron strap and should be so centred that the rods, when tightened, will lie against the sides of the outer side pieces and act as stiffeners for them. With this arrangement, by merely loosening the crank nut on the end of the rods, when the concrete has sufficiently set, the end and side pieces may be removed without disturbing the posts and placed on a similar bottom board, and another batch of posts may be made. The first batch should be left on the bottom board, as will be explained later.

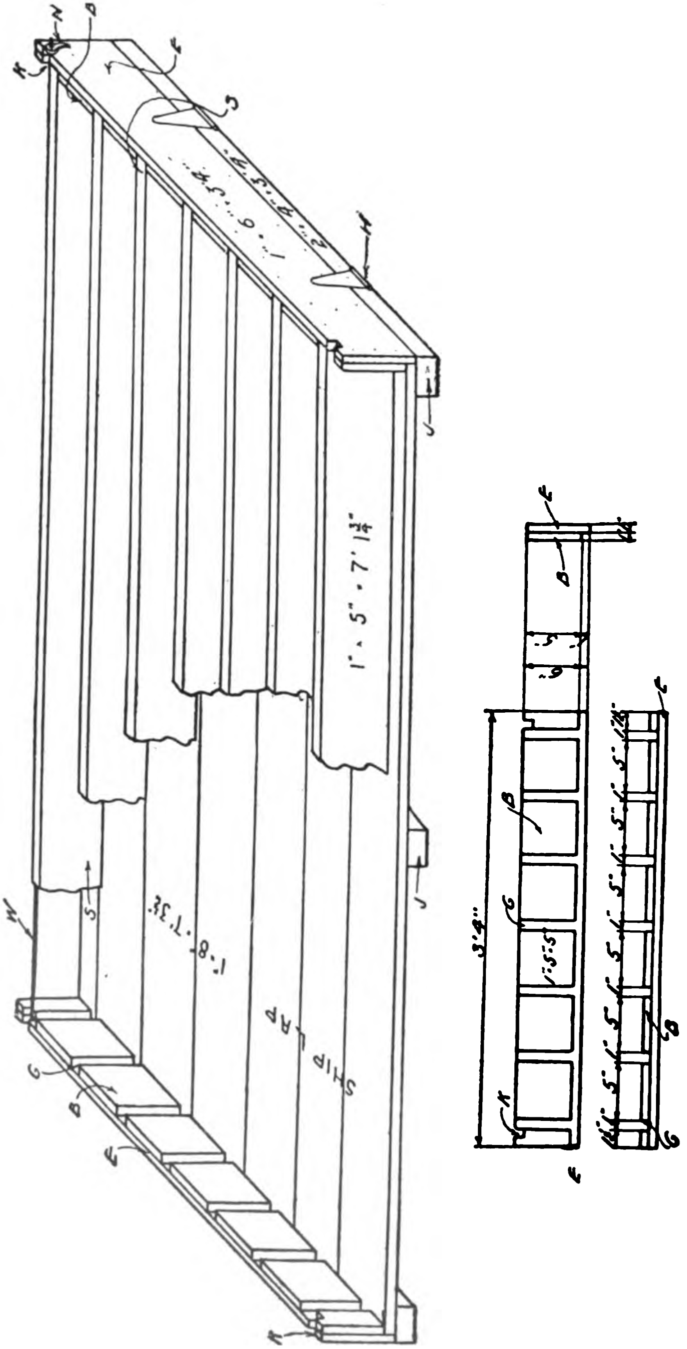


Fig. 1. Gang Mould for Posts without Taper.

By another method the end piece is hinged to the bottom like the end gate of a spring wagon bed, and the method of fastening is the same as generally used on spring wagons—spring elbow catches fastened with screws to the sideboards and flush with them—so as to allow the concrete to be "struck" when the moulds are filled. If the

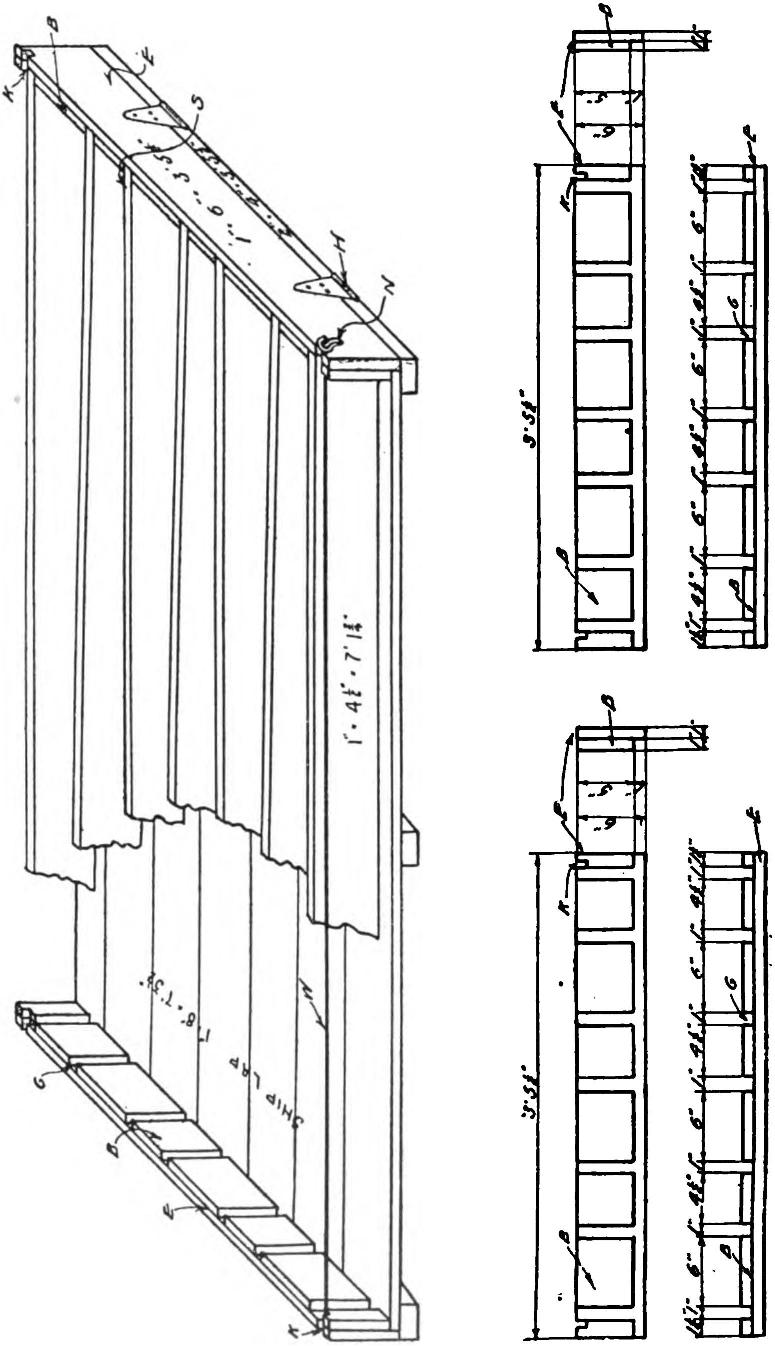


Fig. 2. Gang Moulds for Posts Tapering on Two Sides.

moulds are constructed in this way, the outer sideboards should be made of 2-in. lumber.

For Posts Tapering on Two Sides.—Posts tapering on two sides are preferable to the straight posts in some respects. A satisfactory size for this style is produced in a mould 4½ in. deep by 6 in. wide at the butt, 4½ in. by 4½ in. at the top, and 7 ft. long.

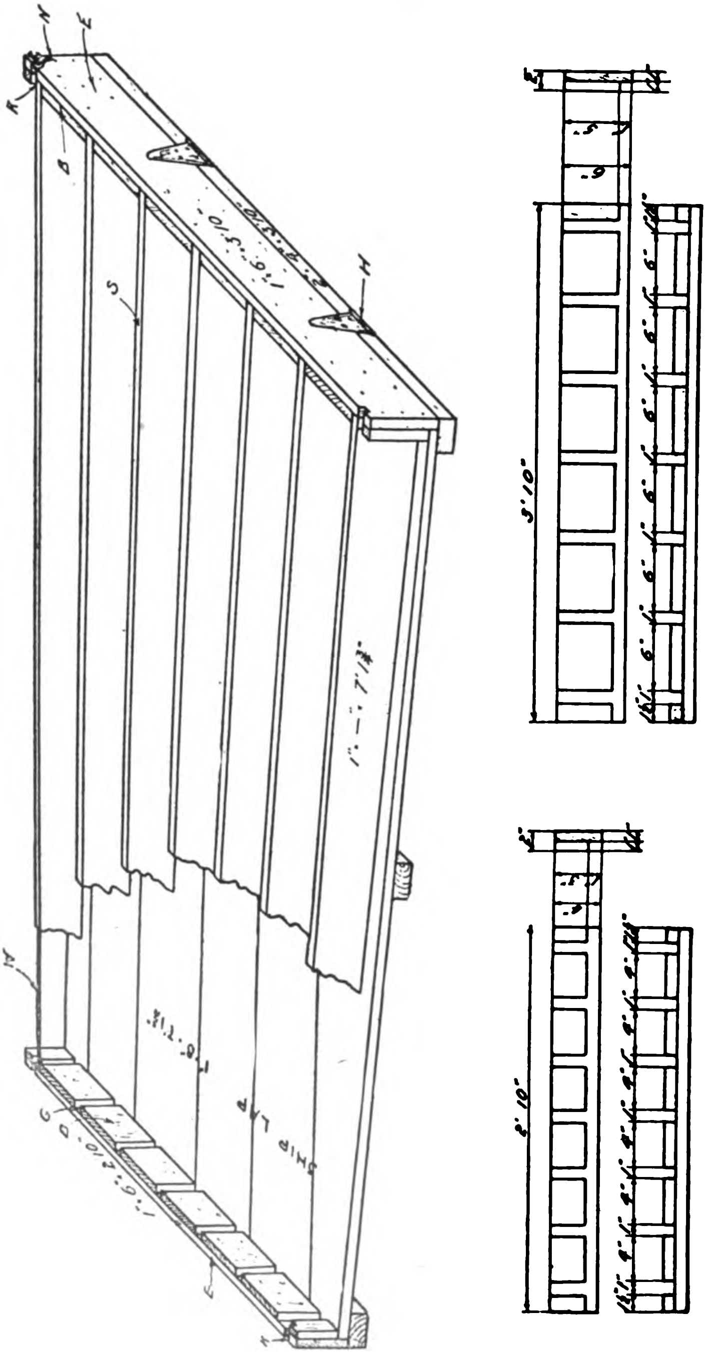


Fig. 3. Gang Mould for Posts tapering on All Sides.

These posts may be made more easily in gang moulds, which are built so as to make the adjoining posts lie butt to top. By considering that the end positions of every post are reversed, it is possible to build this style of mould according to the directions set forth under straight moulds. (*Fig.* 2.)* All dimensions for this mould should be taken carefully from *Fig.* 1.

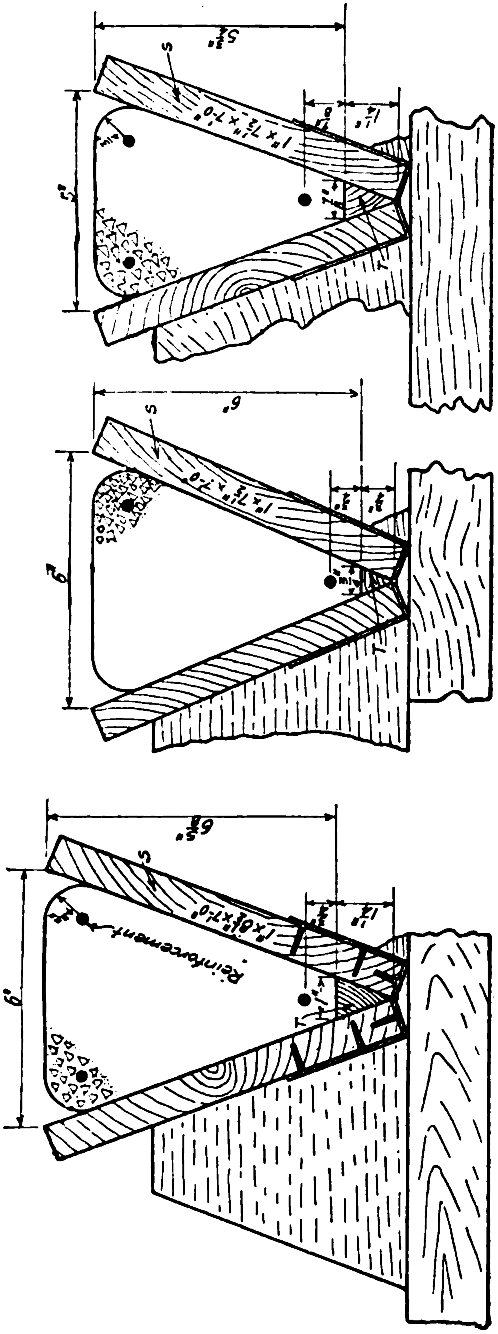


Fig. 4. Moulds for Triangular Posts.

For Posts Tapering on All Sides.—Square posts are also made tapering on all sides. A line post of a satisfactory size may be obtained by making the moulds 5 in. deep by 6 in. wide at the butt, 3 in. deep by 4 in. wide at the top, and 7 ft. long. Since all the butts must be placed at one end and all the tops at the other, this arrangement causes the continuous bottom in *Fig.* 3 to be 1 ft. wider at one end than at the other. The variation in the length of the sideboards and of the moulded posts is, however, so slight (hardly one-fourth of an inch at the greatest) that no attention need be paid to it and all sideboards can be made the same length. The construction of the mould will easily be understood from *Fig.* 3, and from the description of the end pieces, with the manner of hinging and fastening them to the side pieces, as given under straight moulds. All the dimensions for this mould must be taken carefully from *Fig.* 3.

Moulds for Triangular Posts.—Triangular, moulds without a taper are easily constructed in "sets" or "gangs." On account of their shape, they may be braced at any point and, as a result, 1-in. boards may be used in their construction. In *Fig.* 4, moulds for three sizes of triangular concrete posts are shown. The two boards are hinged together at the ends and quarter points on the bottom by ordinary 3-in. wrought-iron strap hinges bent to conform to the shape of the mould and fastened with ¾-in. screws.

Sharp corners on the finished post are somewhat objectionable, on account of their roughness and sharpness, and the possible waste of material. This undesirable feature is avoided by placing a wooden tongue or strip (T) in the bottom of the form, as shown in *Fig.* 4, and by rounding the corners at the upper face either with a trowel or an edger.

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* The letters indicating the various parts are the same as used for straight moulds and in the paragraph discussing them.

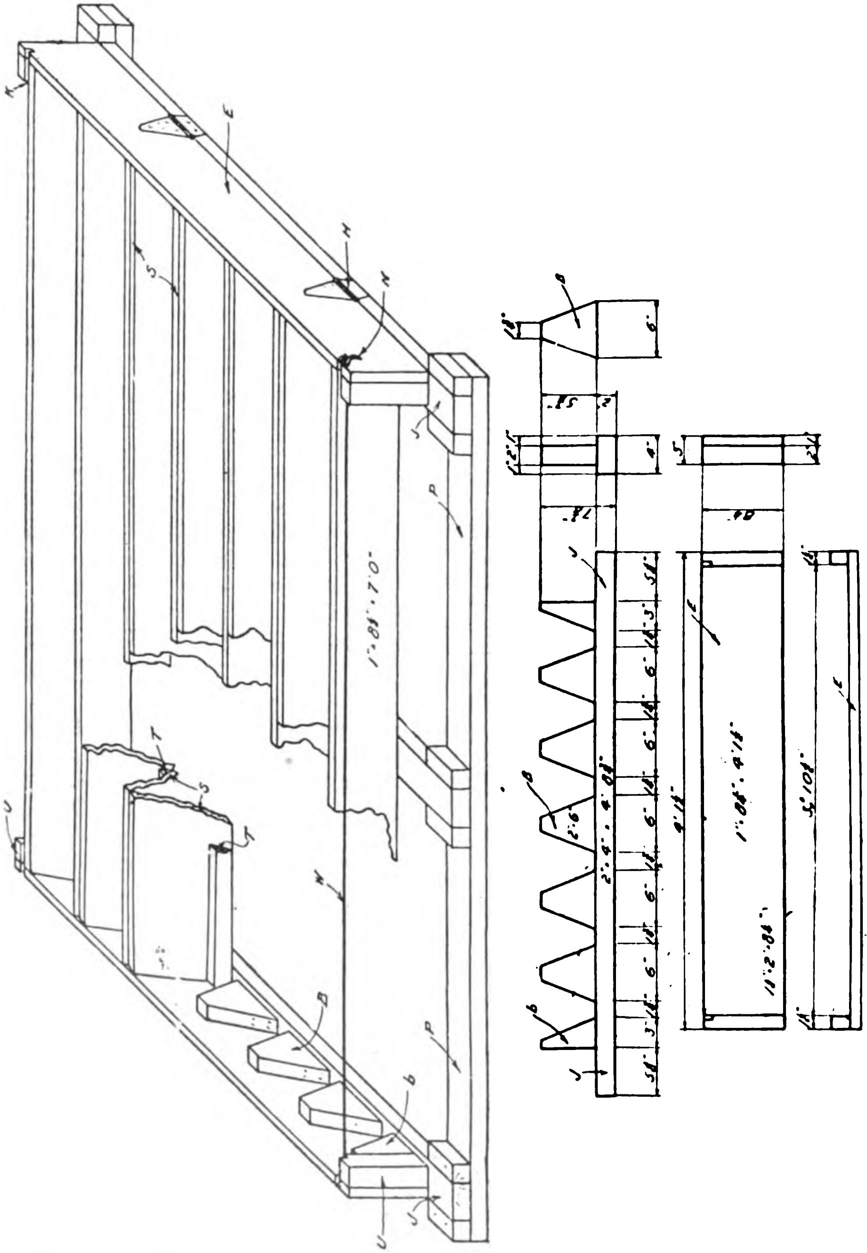


FIG. 5. GANG MOULDS FOR TRIANGULAR POSTS.

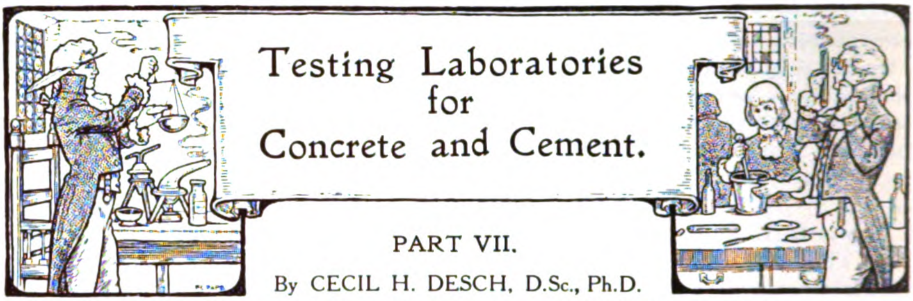
The manner of supporting and bracing the gang triangular mould is shown in *Fig.* 5. Three 2-in. by 4-in. joists (J) should be cut with each 4 ft. 8¾ in. in length. Beginning at either end, 3⅝ in. should be laid off for the cleated lock piece (P) made of a 2-in. by 4-in. board with cleats of strips 1 in. by 2 in. by 3⅝ in. The lock piece laid under the joists, as shown, serves to bind them together. Then 1½ in. should be marked off for the strip (U) on the end board, 3 in. for a half brace block (b), and afterwards 1¾-in. openings for the insertion of the hinged sideboards (S) and 6 in. for the full brace blocks (B), until six posts are provided for, with a half brace block, strip, etc., at the other end. The brace blocks (B) are cut from scantling 2 in. by 6 in. They are 5½ in. deep, and are 2 in. wide at the top and 6 in. at the bottom, where they are nailed to the joist (J).

The ends (E) for the moulds are made from 1-in. by 10-in. boards and are 4 ft. 1½ in. long. They are fastened, at the bottom side, to the joists (J) by means of heavy, loosepin wrought-iron strap hinges, shutter hinges, or door butts (H), and at the upper side with wagon rods (W) and wing nuts (N) or with elbow catches (see also *Fig.* 3). Until all of the moulds of the gang are partially filled with concrete, it is sometimes necessary to keep them from spreading open at the centre by using a tie brace made from a 2-in. board with blocks of 1 in. in thickness attached so as to fit the moulds when the brace is in place.

With slight changes, similar forms may be built for medium and light posts. Triangular posts tapering on all sides can be built, but the moulds are difficult to construct, and the amount of material saved is not worth the trouble.

Oiling the Moulds.—Concrete has a tendency to stick to either steel or wood. In order to yield a smooth finish to the post, it is customary to give the inside of the moulds a coating of oil. Soft soap or crude oils used sparingly serve the purpose well. Too much oil will destroy the setting qualities of the cement and will give a face roughened with pockmarks. A small amount of oil, poured into a pail of water and applied with a mop or stiff broom in scrubbing out the moulds after they have been used five or ten times, or as often as necessary, will prevent the concrete from sticking.

(To be continued.)



Testing Laboratories for Concrete and Cement.

PART VII.

By CECIL H. DESCH, D.Sc., Ph.D.

The absence of an official laboratory devoted to investigations with concrete and cement may be said to account in no small degree for the dearth of reliable data as to reinforced concrete as designed and executed in this country.

Some testing station enjoying official support, or if conducted by some independent technical body at least enjoying official recognition, would be very much in place at the moment, and it might be a matter worthy of the attention of the Concrete Institute to consider the possibility, and ways and means of obtaining for the British Empire some laboratory of this description.

We have presented particulars of a number of laboratories in preceding articles, and in the present case we deal with one conducted as a private industrial enterprise, particulars of which have been taken from "Armiester-Beton."—ED.

THE TESTING LABORATORY OF MESSRS. GERHARD HERFELDT, AT ANDERNACH (RHINE).

By ANTON HAMBLOCH, ANDERNACH.

THE immense growth of industry in the last few decades is owing in great part to the advances in the production of materials. Whilst quite recently even large industrial concerns were provided with an equipment from our modern point of view highly clumsy, there is now a continual struggle of novelties anl improvements, and we may speak of a campaign of industry which aims at universal conquest, so that the most difficult problems appear capable of solution.

Great and successful attempts have been made in all branches of industry to increase our knowledge of the properties of materials, with the object of utilising them to better advantage—that is, to increase as far as possible the yield from the raw materials. Martens says in his "Handbook of Materials for the Construction of Machines":

"The industrial utilisation of the latent capacities of a raw material is incomplete if the material produced from it does not possess all the good qualities which it can develop or acquire by means of a commercially practicable process of preparation."

This rule is not merely applicable to the materials of machine construction, it is of very general importance and may rank as a rule of experience which has been followed by the leading industrial organisations, not only on their own behalf, but on that of the industry and in the interest of the public. If the smaller producers are not in a position to provide themselves always with what is newest, yet they are able to accommodate themselves to the process of development as far as possible according to their means.

It is a grateful duty to acknowledge here how greatly the industry has been assisted in its efforts towards continual improvement by the national stations for the testing of materials. Not only have these stations rendered the service of perfecting the methods of testing all kinds of materials, but they have given to many engineers the stimulus and training enabling them to pursue the extraordinarily important work of testing, and to co-operate in seeking the above-named goal. So a great number of laboratories for the testing of building and structural materials have arisen in industrial concerns, where they serve the special needs of the works. However, the exchange of experience which goes on, particularly through their relation to the parent laboratories at the technical colleges and through the associations for the testing of materials, causes these private institutions to contribute in the most useful manner to the full recognition of the present importance of the testing of materials for all branches of industry.

The necessity for erecting such testing laboratories arises also in another way, from the increasingly prevalent practice of buying materials according to specification—that is, by testing them for the required properties. This practice is of as much advantage to the selling firm as to the buyer.

The writer has had charge for a number of years of a laboratory of this kind, belonging to the firm of Gerhard Herfeldt, in Andernach, which was conducted, not only for routine testing, but more particularly for purposes of investigation. Numerous experiments have been performed there relating to the use of trass mortars for valley-dams, as well as for canal, dock and harbour works, and for buildings. I have also made extensive investigations with the object of furthering our knowledge of the behaviour of trass mortars for the most varied purposes, as well as researches on the process of hardening of trass mortars and the improvement of methods of testing trass and mortar. It was a special task of the last few years to study the utility of trass when mixed with cement. I may refer to my published works for this branch of activity.

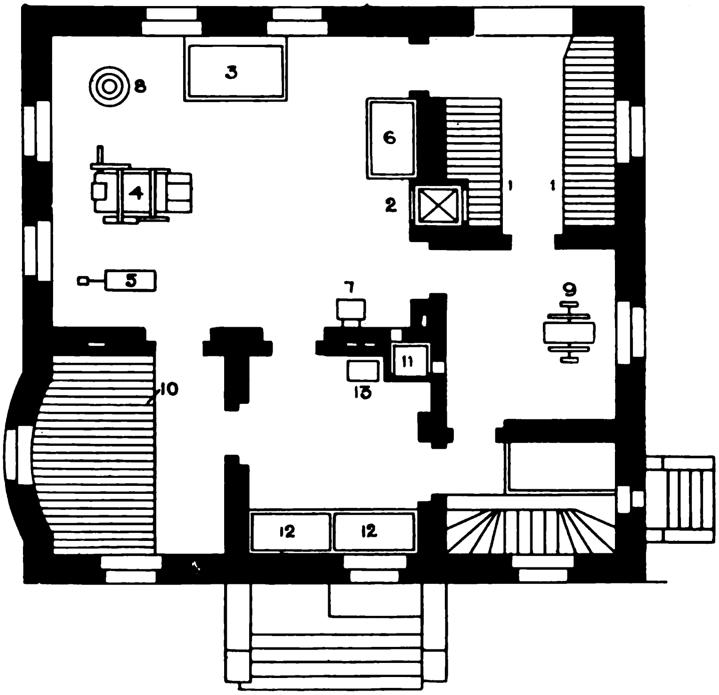


Fig. 1. Plan of lower floor.

Testing Laboratory of Messrs. Gerhard Herfeldt at Andernach.

The continually increasing demands on the laboratory made an enlargement necessary, which, however, in view of the necessities of future equipment, took the form of an entirely new building, the extent and arrangment of which forms the subject of the following account, which may be of interest and perhaps of use to my confrères in the industry.

The Building and Equipment.—The new building is erected on a plot of 762 square metres on the Coblentz road at Andernach, about 200 square metres being covered by the laboratory and other buildings. (See plans, *Figs.* 1 and 2.) The building was begun in April, 1909, and was ready for work on November 15th, 1909. The working rooms are on an upper and lower floor, the attic floor is occupied by the laboratory attendant. The equipment is as follows, the apparatus, etc., being numbered :

Lower Floor (*Fig.* 1).—(*a*) ***Store for Materials;*** 1, wooden racks on the floor and walls for storing dry materials; 2, goods lift for raising materials to the upper floor.

(*b*) ***Concrete and Mortar Room;*** 3, tank for lime paste; 4, concrete mixing machine by Gauhe, Gockel & Co.; 5, lever weighing machine by Garvens; 6, tank for storing large concrete specimens under water; 7, large muffle furnace for high temperatures; 8, volume measures of 5, 10, 25 and 50 litres capacity.

(*c*) ***Grinding Room;*** 9, ball mill by Amme, Giesecke & Konegen.

(*d*) ***Store for test pieces and vessels;*** 10, wooden racks on the floor and walls for arranging concrete moulds, rammers, spare machine parts, and vessels.

(*e*) ***Heating Room;*** 11, central heating apparatus (Riessner furnace) with fresh air inlet from outside, by a channel passing underneath the grinding room; 12, bunkers for coal and coke; 13, movable container for ashes.

Upper Floor (*Fig.* 2).—(*a*) ***Material Room;*** 1, wooden racks on floor and walls for dry storage of materials; 2, two bins for normal and ordinary sand.

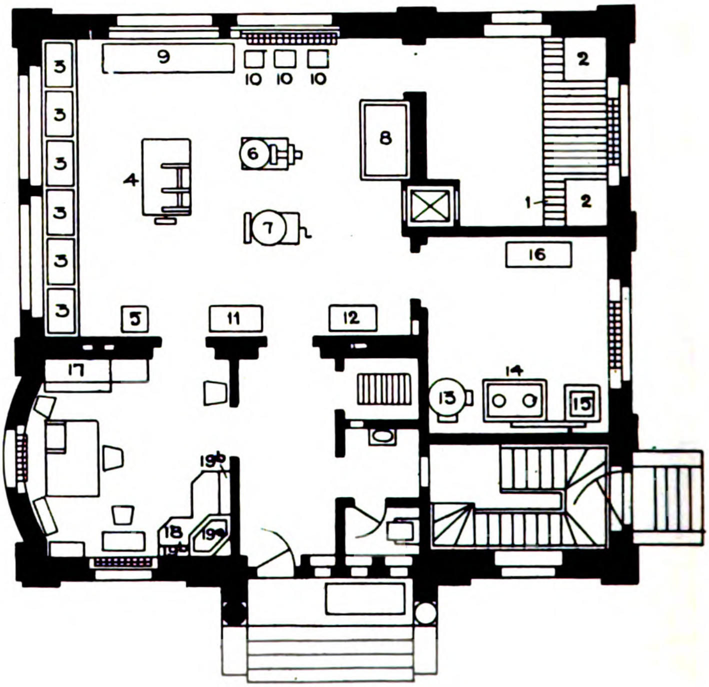


Fig. 2. Plan of first floor.
TESTING LABORATORY OF MESSRS. GERHARD HERFELDT AT ANDERNACH.

(*b*) ***Mortar Room;*** 3, granite tanks for hardening in water and for tests in sea water and acids; 4, standard Böhme apparatus with three hammers; 5, table with Tetmajer permeability apparatus; 6, Steinbrück-Schmelzer mortar mixer; 7, Hambloch's standard edge-runner for trass tests; 8, chamber for tests in moist air; 9, working bench with Frühling-Michaëlis tensile testing machine (this machine is provided with special appliances for bending tests and for tests of adhesion); Michaëlis's apparatus for removing test-pieces from moulds; Vicat's needle apparatus, balance, measuring vessels, etc.; 10, mortar vessels; 11, working bench with Tetmajer's sifting apparatus, hygrometer, and apparatus for the determination of apparent density; 12, working bench with three volumenometers for the determination of specific gravity (Michaelis, Thörner and Erdmenger-Mann).

(*c*) ***Machine Room;*** 13, 32-ton press by Amsler-Laffon; 14, 500-ton Martens hydraulic press; 15, plunger pump for the hydraulic press; 16, cupboard for moulds and apparatus.

(*d*) ***Laboratory and Office,*** containing besides an ordinary office equipment; 17, reagent cupboard; 18, cupboard for drying apparatus, ignition furnace, and chemical apparatus; 19a, enclosed quantitative balance, microscope, lenses, and Bauschinger's micrometer; 19b, shelves for filter-stands, wash-bottle, flasks, test-glasses, dialysers, etc.; 20, shelves for other apparatus, pipettes, capped flasks, etc.

In the masonry, concrete and stucco work, Plaidter (Nettetal) trass was used in all the mixtures, in order to show the range of applicability of trass. The foundations were of concrete, composed of 1 vol. trass, 1 vol. white lime cream, 5 vols. sand, and 15 vols. broken brick. The masonry of the lower floor is of schistose stone, set in a trass-lime mortar of 1 vol. trass, 1 vol. lime cream, and 5 vols. sand. The masonry of the upper floor is of Rhenish pumice, set in the same lime-trass mortar.

Floors. —The basement floors are of concrete with cement finish, the mass being of 1 vol. trass, 1 vol. lime, 4 vols. sand, and 6 vols. Rhenish gravel, and the surface of 1 vol. trass, 1 vol. lime, and 4 vols. sand. The vaulting above this floor is of concrete composed of 1 vol. trass, 1 vol. cement, and 8 vols. pumice, part of which serves as sand. The floors above this are of mosaic, set in mortar composed of 1 vol. trass, 1 vol.cement, and 5 vols. sand. The laboratory and office floors are of linoleum over cork flooring.

Plastering and Stucco.—The internal surfaces are finished with mortar composed of 1 vol. trass, 1 vol. lime cream, and 4 vols. sand, and the external surfaces of 1 vol. trass, 1 vol. lime cream, and 5 vols. sand. For the external work a very pleasant effect was obtained by combing the finished surface after about 24 hours, and therefore before hardening, with iron teeth. The coarse sand and trass-lime mortar give a granular surface, which is very resistant when once hardened, whilst its porosity allows the wall to dry.

The tanks on both floors for storing test-pieces under water and in moist air are of trass-cement concrete, floated with trass-cement mortar. The walls are very thin, and composed of 1 vol. trass, 1 vol. cement, and 3 vols. sand.

In all the mixtures Rhine sand was used in the condition in which it is delivered by the dredger for building purposes. In the concrete, except for foundations, where, as described above, broken brick was used, the aggregate was Rhine gravel in its usual state, containing both large and small pebbles.

The reason for using trass so extensively in the work is that it was desired to show, in the finished structure, that trass, properly used in combination with either lime or cement, is an excellent material for mortar for all kinds of building purposes. Cement was used in the concrete mixtures for the vaulting, tanks and floor surface, on account of its more rapid hardening, with a view to hastening the completion of the structure. The results of these different applications, both of trass-lime mortar and of trass-cement mortar, are to be described as in the highest degree satisfactory.

The firm of constructors and architects, Kroth & Linz, Andernach, deserve an acknowledgment of the care and good taste with which they have carried out the construction of the building.

THE CHOICE OF REINFORCEMENT.

Further Contributions.

The choice of a suitable reinforcement in reinforced concrete work is a matter of the utmost importance, and the present contribution on the subject calls for attention.

Views on the subject are still very divergent, and those associated with the sale of special forms of bars are apt to take an optimistic view of the value of their particular specialities.

In our August issue (page 552) we published an article of the optimistic character referred to, and whilst intimating that we did not associate ourselves with the views expressed—either for or against—we opened our columns to those who have something to say on the subject.

In our September issue we presented a spirited reply from the pen of another correspondent, and we now publish some further contributions, one of which is the special pleading of a firm interested in indented bars.—ED.

A REPLY BY THE ORIGINAL CORRESPONDENT.

In the September issue of Concrete and Constructional Engineering, an article appeared criticising the original article which appeared in your August number, and the author of the original article would like to make a few comments on this criticism.

In the first place, the original article deals with technical matters, which are of importance to engineers; and it seems a pity that comments cannot be confined to criticism of a technical nature, and that the critic should go out of his way to imply commercial motives to the writer of the article.

The author, however, does not intend to deal with any such question, but only with a few technical questions which are of interest.

The writer of the September article states—referring to the original article—"The writer has carefully read the ingenious but absolutely imaginary proposition of your correspondent on the subject of crack prevention. His exposition reads very well, and may appear convincing to the uninitiated. It is based on two gratuitous and perfectly inaccurate assumptions: (1), that cracks cannot appear without some slipping of the material; (2), that indentations or projections limit the size of cracks."

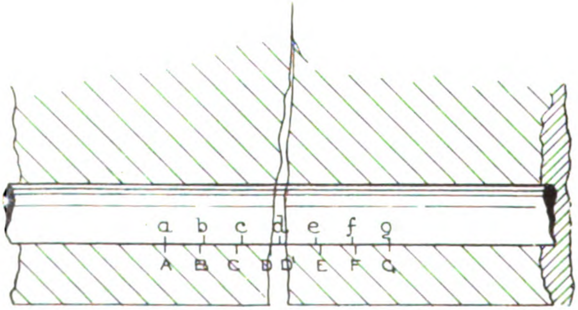


Diagram of Crack in Reinforced Concrete.

As regards the first of these assumptions, it seems difficult to imagine how an engineer evidently experienced in reinforced concrete can deny such an obvious truth. The adjoined diagram showing a crack at the bottom of a beam and a steel bar crossing such a crack shows on an enlarged scale what happens when a crack of this kind takes place. Before the crack occurred the two points marked D and D′ coincided with each other, and also with a point marked d in the steel. When the crack occurred it is obvious that both the points marked D and D′ must have slipped along the steel by the distance D d and D′ d. This appears so absolutely obvious that it is difficult to realise that it should present any difficulty to anyone who thinks about the subject at all. If we consider the several points a, b, c, and e, f, g along the bar, it is obvious that in their new position they will be as shown on the diagram, and that the amount of slipping will gradually increase from nothing at the points A and G to a maximum at the point D.

If one were to deny, as your correspondent has done, that slipping must occur when a crack appears, then it would be interesting to ask where the piece of bar comes from which is now visible through the crack. It should be noticed that it makes no difference what the size of the crack is. Cracking cannot occur without slipping of the concrete round the reinforcement, however small such slipping may be.

It is obvious that the rest of the article must have been quite lost on your correspondent, as it all rests on the truth of this proposition.

The second point, for instance, that indentations or projections limit the size of cracks, will at once follow when it is conceded that cracking involves slipping, and that slipping is better prevented when mechanical bond is provided than when the reinforcement consists of smooth bars.

THE VIEWS OF MR. R. W. VAWDREY, B.A., A.M.Inst.C.E.

(Chief Engineer, Patent Indented Steel Bar Company.)

If the author of the first article under this heading in the August number of Concrete set out with the intention of deliberately provoking his opponents on the question of smooth bars *versus* corrugated, he must surely be well satisfied.

As the author of the reply printed in your September issue has seen fit to concentrate his attack on corrugated bars made of high-carbon steel and has suggested that the original article was written in the interests of parties concerned in the sale of such bars, it may not be out of place for the Indented Bar Company, Ltd., which is the firm to which the above description would most closely apply, to make their position clear as to the points raised by the two articles.

It will be necessary to refer continually to the two articles in question, and it will be well, therefore, to call them respectively Article No. 1 and Article No. 2.

QUALITY OF STEEL.

In the first place, Article No. 1 mentions the employment of a stress of 20,000 lb per sq. in. In order that this stress may not exceed half the elastic limit of the steel—a condition which is required by the rules of the R.I.B.A. and most other standard authorities—it is not by any means necessary to use what is technically known as high-carbon steel. A medium steel having an elastic limit of 40,000 lb. per sq. in. and an ultimate strength of about 75,000 lb. per sq. in., will have a percentage of about 0·25 of carbon. This is very far from being the high-carbon steel so generally and rightly condemned for structural purposes. It is presumably such a steel that the writer of Article No. 1 would recommend, but clearly the authors of both articles are in error in characterising it as "high carbon steel."

The author of Article No. 2 would undoubtedly be correct in speaking of high-carbon steel as brittle if he were referring to steel with such a percentage of carbon as 0·5 or more. But the error he falls into, possibly owing to the mistaken nomenclature of Article No. 1, is to confuse a medium steel capable of carrying 20,000 lb. per sq. in. at less than half its elastic limit, with an extension of, say, 15 per cent. in 8 in., with really high-carbon steel. He appears to ignore the fact that any number of varieties of steel exist between the two extremes of mild commercial steel and high-carbon steel having a percentage of, say, 0·50 of carbon.

The crux of the whole matter consists in the selection of a steel which, while considerably exceeding in tensile strength the ordinary mild commercial quality, is yet sufficiently mild to comply with all the requirements of a reinforcing material as regards bending or other manipulation to which it may be subjected.

It has been proved in our own experience, to say nothing of the enormous extent to which such steel is used elsewhere, that an extension of 15 per cent. in 8 in. is sufficient to fully comply with such requirements.

It is not the fact, as stated by Article No. 2, that such steel is either "brittle," "expensive to bend," or "far more expensive than mild commercial steel." On the contrary, such a medium steel as described above is capable of being bent cold quite as satisfactorily, and as cheaply, as mild commercial steel. The cost is only very slightly, if at all, greater than that of mild steel, the difference being certainly far less than the economy which can be effected by its use.

The argument of Article No. 2 that the modulus of elasticity (which is presumably what is meant by the phrase elastic co-efficient) of high-carbon steel is practically the same as that of mild steel is, of course, true, but the author's deductions from this fact are quite erroneous. He states that the rise in the position of the neutral axis so seriously diminishes the area of compression in the concrete that it becomes impossible to utilise the increased stress made possible by the higher quality of steel. This is partly true in an isolated rectangular beam, but such a beam is of extremely rare occurrence in actual reinforced concrete work, though no doubt considerable prominence has been given to the discussion of such beams in the majority of textbooks on the subject. In practice it is certain that at least 99 per cent. of reinforced concrete beams are tee beams, and in such beams it is perfectly easy to utilise to the full the advantage which a higher class of steel provides. It is true that in a beam which is greatly "over-reinforced" it is impossible to develop the full stress in the steel unless a double system of reinforcement is used. This, however, is perfectly possible even in the rare cases referred to, and a designer who is accustomed to use the stress of 5,000 to 10,000 lb. mentioned in Article No. 2, cannot be considered particularly competent.

MECHANICAL BOND.

Correspondent No. 2 states the assumptions made by No. 1 most clearly and succinctly as follows:

1. Cracks cannot appear without some slipping of the metal in the concrete;
2. Indentations or projections limit the size of the cracks.

He completely disproves these assumptions in a curious but not particularly effective way—he denies them! No other argument is apparently ready to hand! But it is a fact that the first assumption is perfectly correct, and the second also if we add the proviso that the indentations or projections shall be sufficient to prevent slipping, which condition can easily be obtained. Assumption No. 1 is really a truism, and it is difficult to see how it can be denied if the words used are to convey their ordinary meaning. A crack is a separation between consecutive portions of the concrete. If this crack extends to the reinforcement, which is the condition spoken of by both correspondents, it follows that for a length equal to the width of the crack the steel will be exposed. This width is, of course, microscopical only, but it nevertheless must exist if there is a crack, and it is clear that the concrete which was originally in contact with this minute portion of the bar must have slipped from it.

Assumption No. 2 is equally obvious, if it is considered that the question we are discussing is the maintenance of the bond between the two materials.

If the bond due to the adhesion only is maintained, no further assistance in the direction of mechanical bond is required. But it is surely clear that the provision of a mechanical bond in no way decreases, but actually increases, the mere adhesion of the concrete to the steel (this being partly due to the contraction of the former during the process of setting) in addition to the absolute mechanical bond which is also provided. The single crack mentioned by Correspondent No. 1 as capable of amounting to $\frac{1}{500}$ of an inch in a length of 3 in. can only occur if the adhesion bond over this length of 3in. has failed, and it is therefore beside the mark altogether for Correspondent No. 2 to state that the invisible cracks which would occur if the adhesion remained perfect, would be greatly less than the single crack in a length of 3 in., which would only take place if the adhesion bond (as opposed to the mechanical bond) had failed. His arguments amounts to the statement that if cracks occur only at every 3 in. they will be hundreds of times wider than if they occur, say, at every $\frac{1}{1000}$ of an inch. This is quite true, but hardly leads to the conclusion he desires! The essence of the whole question is how best to maintain the bond between the two materials. The results of experience go clearly to show that the adhesion of concrete to steel may be perfectly satisfactory if the workmanship in every portion of the length of a beam is perfect, and that this adhesion is greatly aided by the use of a mixture of concrete very rich in cement. (The cause of this being probably due, at any rate to some extent, to the greater contraction during setting of a rich mixture.) But while good adhesion to smooth bars may no doubt be obtained, a bar such as the corrugated or indented bar will slightly increase even the adhesion, owing to its increased area of surface, and, in addition, will provide an absolute mechanical bond with the concrete. It will, therefore, maintain the bond intact even though the adhesion may become faulty in places through poor workmanship, diminution of the sectional area of the steel under stress, shocks, vibration, or other causes.

In other words the use of a satisfactory mechanical bond eliminates one of the many risks of improper workmanship in small detail, which are inseparable from practical work. In spite of the fact that laboratory tests with smooth bars as a rule show excellent adhesion results, it should be remembered that some large and important reinforced concrete structures have not done so.

It would be interesting to know what are the "costly and troublesome methods" which are supposed by the author of Article No. 2 to attend the use of corrugated or indented bars as compared with smooth bars.

So far from the use of indented bars increasing the amount of labour involved, the chief difference which exists between the two cases, is that where smooth bars are used it is universally recognised as necessary to split and fishtail, or otherwise anchor the ends of every bar. This is surely a sufficient recognition of the necessity for a mechanical bond, even though in this way it is only obtained at the ends of a bar instead of throughout the whole length. The extra cost of this splitting, hooking, etc., including the extra handling involved, is found in practical work to be a by no means negligible item.

In view of the references in Article No. 2 to laboratory tests, it may be of interest to state that some tests recently carried out by the Government of Western Australia (per F. W. Lawson) in order to ascertain the difference between the bond of smooth bars and indented bars, have given the following results, special care having been taken to obtain results of as practical a nature as possible without any attempt to show startling figures.

ADHESIVE STRENGTH BETWEEN CONCRETE AND BARS.

Smooth	Round bars	170	lb. per sq. in.
	Square bars	181·5	,, ,,
	Indented bars	453·6	,, ,,

In this, as in some other cases, the laboratory tests so often referred to in Article No. 2

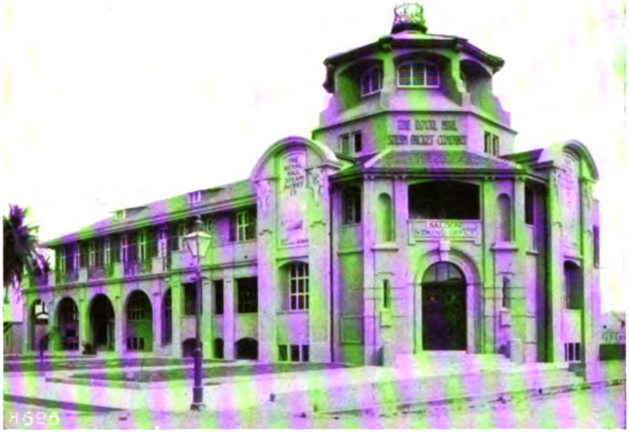
do not by any means cover the whole field of circumstances met with in practical work, but as a matter of fact even in such tests far higher adhesion or bond values have been obtained with indented bars than the figures given by your correspondent, and as is shown above the advantage lies very clearly with the mechanical bond bar.

The views of Prof. Mörsch, of Zurich, are referred to by Correspondent No. 2 as indicating the dangers of the splitting of the concrete, especially in small beams, by the projections on a mechanical bond bar. This is obviously possible if the projections have a flat sloping surface which may tend to produce a wedging or bursting action. If, however, the projections are at a sufficiently steep angle, no such action can or does occur, and it is not, as a matter of fact, to indented bars, but to another form of mechanical bond bar, that Prof. Mörsch refers. This last fact is carefully ignored in Article No. 2.

It is, by the way, a curious coincidence that the same statement of Prof. Mörsch as to the danger of a particular form of mechanical bond bar (*not* the indented bar) has also been referred to in an article which appeared recently in the trade publication, *Ferro-Concrete.*

Can it be that the energy of Correspondent No. 2 in attacking those whom which he erroneously supposes to be advocates of the sale of high-carbon steel is after all to be explained by his connection with a competing company?

R. W. Vawdrey, B.A., A.M.Inst.C.E.,
Chief Engineer to Patent Indented Steel Bar Co., Ltd.

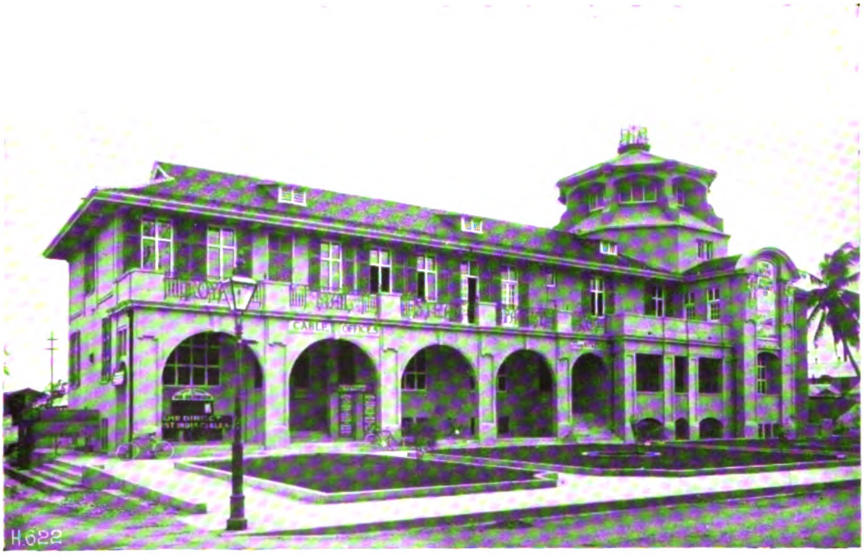


ROYAL MAIL STEAM PACKET COMPANY'S OFFICES, KINGSTON, JAMAICA.

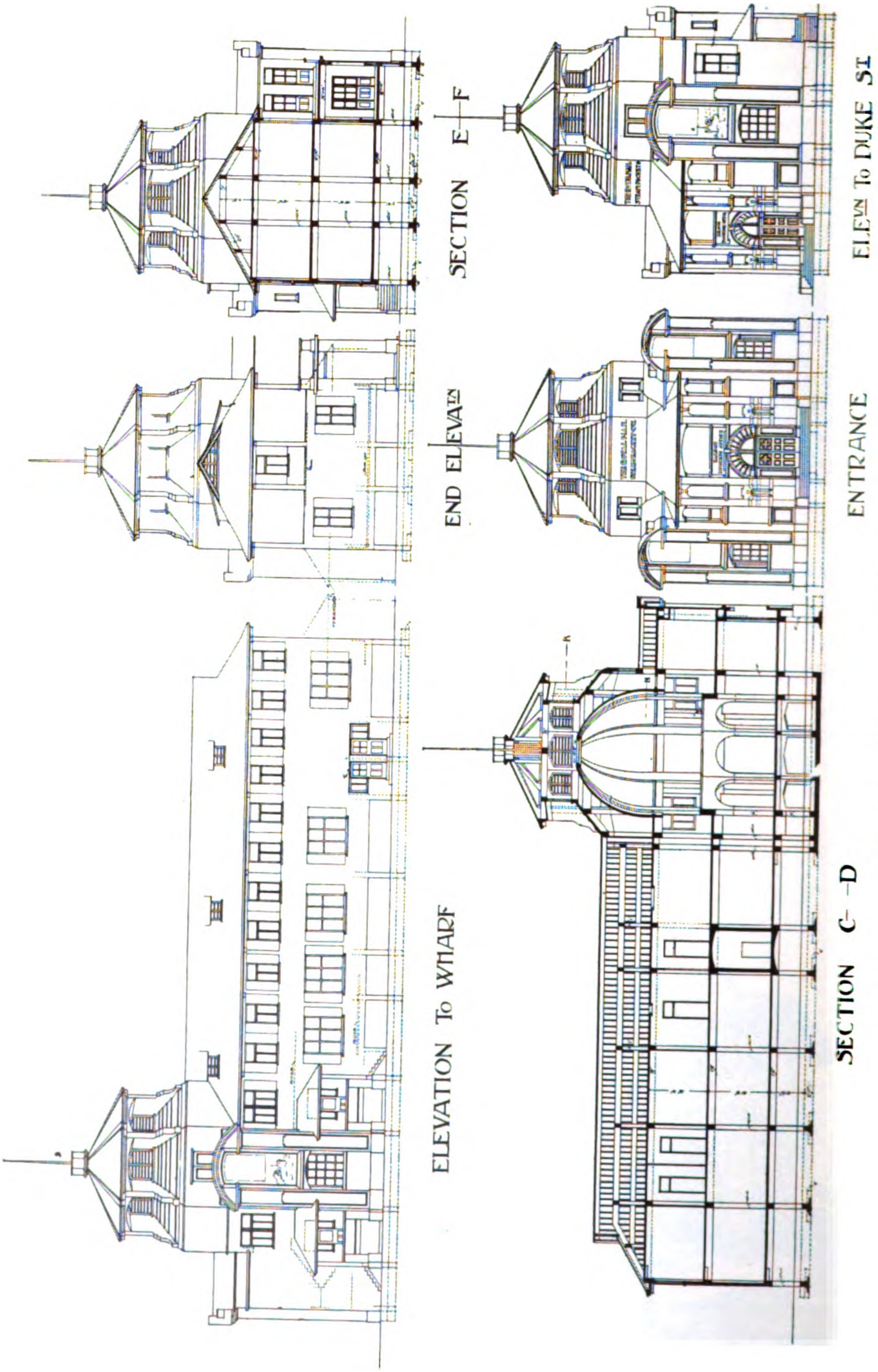
The new offices for the Royal Mail Steam Packet Company's Offices at Kingston, Jamaica, are a striking example of the use of reinforced concrete in earthquake districts, and they also show the architectural possibilities of this material.—ED.

THIS building has been erected to replace the Royal Mail Offices at Kingston, Jamaica, which were destroyed by the earthquake, and is a striking example of the possibilities of reinforced concrete.

The site is a large one, and provides accommodation for five store sheds,



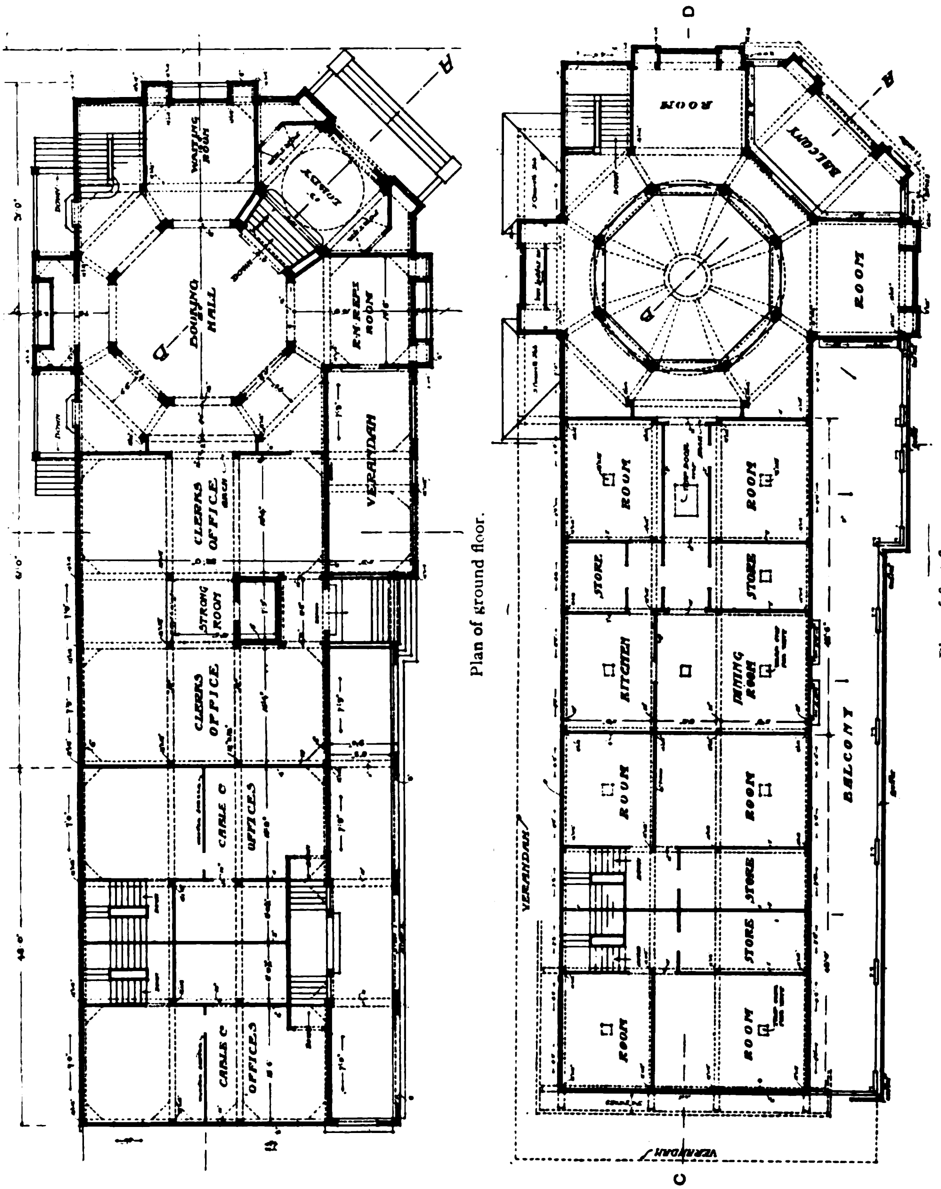
ROYAL MAIL OFFICES, KINGSTON, JAMAICA



Royal Mail Offices, Kingston, Jamaica.

each to hold 1,500 shipping tons ; also offices for passengers, baggage, and Customs offices, as well as large stores for coal, etc., etc.

The building is constructed upon a reinforced concrete raft formed of flanged concrete with inverted reinforced beams, to withstand upward shock, the beams being continuous throughout the building. The greatest load on any column is 49.29 tons, on the basis of 100 lb. live load and 60 lb. dead load on floors.



Plan of ground floor.

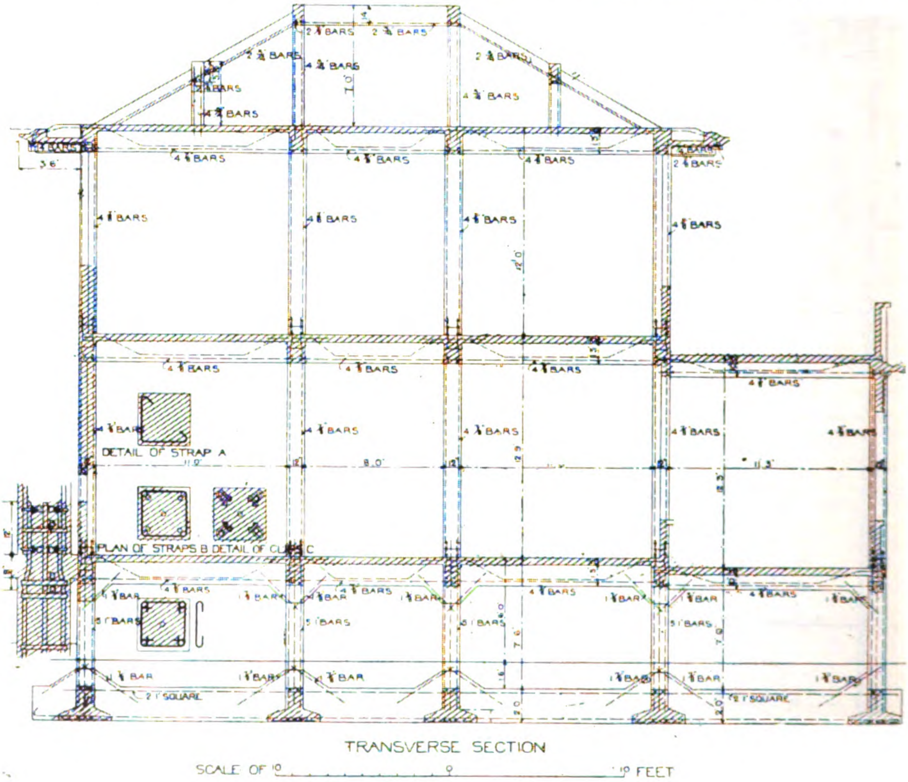
Plan of first floor.

ROYAL MAIL OFFICES, KINGSTON, JAMAICA.

The ground floor is 6 ft. 6 in. above road level, and this helps to give great stability to withstand earthquake shock, since the building was required to be fairly high, to act as a landmark from the harbour.

The floors are all finished 4 in. thick, upon continuous beams, flanged to outer columns and finished 6 in. by 6 in. red quarry tiles. The floors and steps of the main booking hall and entrance vestibule are, however, paved with Silician and Swedish green marble, prepared and supplied by the Art Pavement Co., of London.

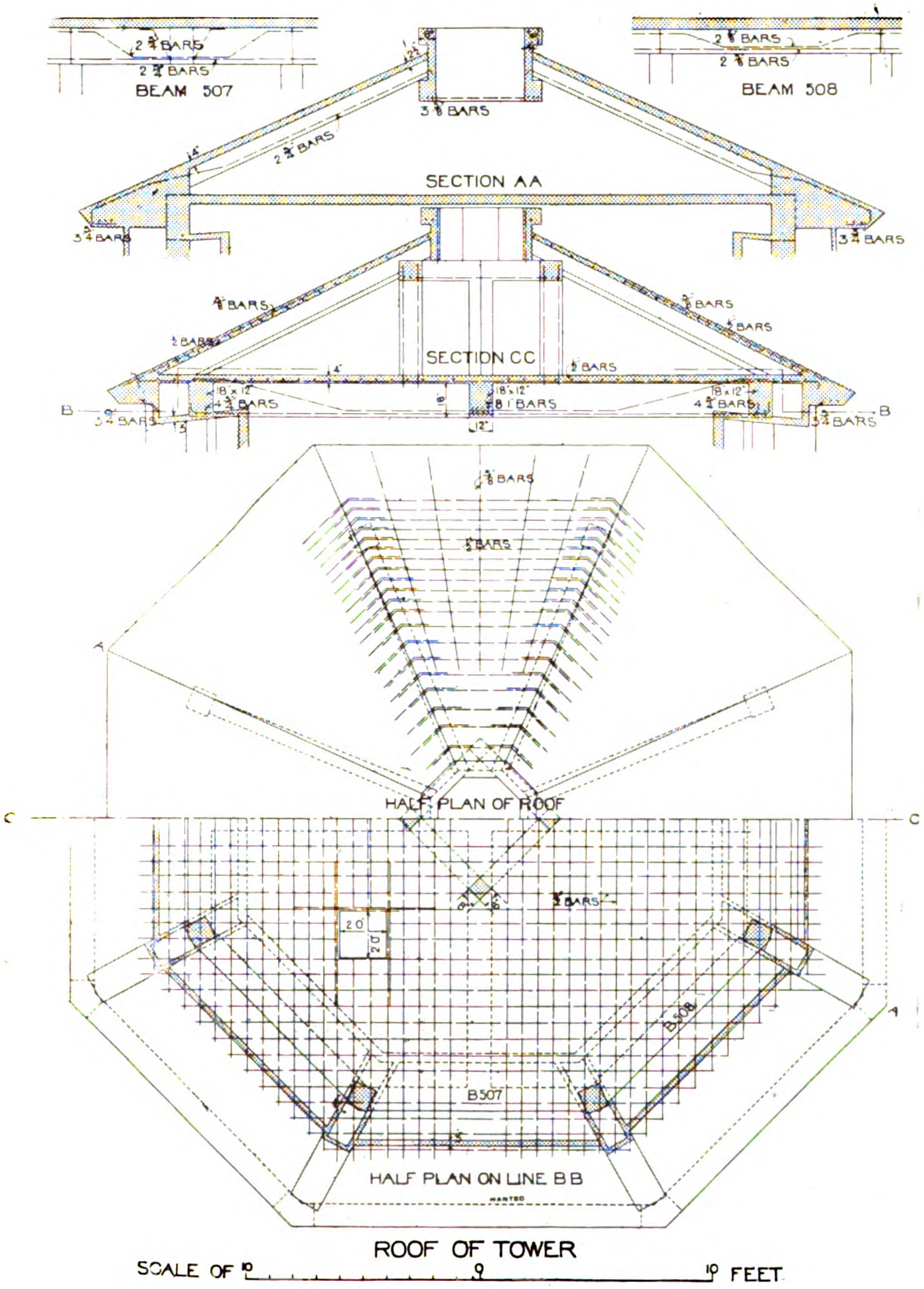
The roof, trusses, and purlins are made of reinforced concrete with steel bolts formed *in situ* to take timber plates and rafters, etc. The main portion of roof has been covered with heavy English glazed red roofing tiles, each secured with two copper nails. The dome is covered with copper sheeting fixed to hardwood fillets built into concrete. This copper work has been prepared by Messrs. Braby & Co., and was sent out moulded, etc., ready for fitting.



Transverse section through reinforced concrete construction.
ROYAL MAIL OFFICES, KINGSTON, JAMAICA.

One of the special features of the offices is a tower which is constructed upon continuous reinforced concrete columns tied together at the floor, and above the inner dome, forming the ceiling of the first-class booking hall. An iron stairway gives access to the balcony over the dome, which is used for a Morse signalling apparatus.

The booking hall is panelled in West Indian mahogany, the spandrels and



Detail of roof of reinforced concrete tower.
ROYAL MAIL OFFICES, KINGSTON, JAMAICA.

soffits of the eight arches being carried upon panelled pilasters. Over the centre of the arches are carved panels bearing the monogram of the company, and various dates of interest in its history, surmounted by a richly carved foliated moulding.

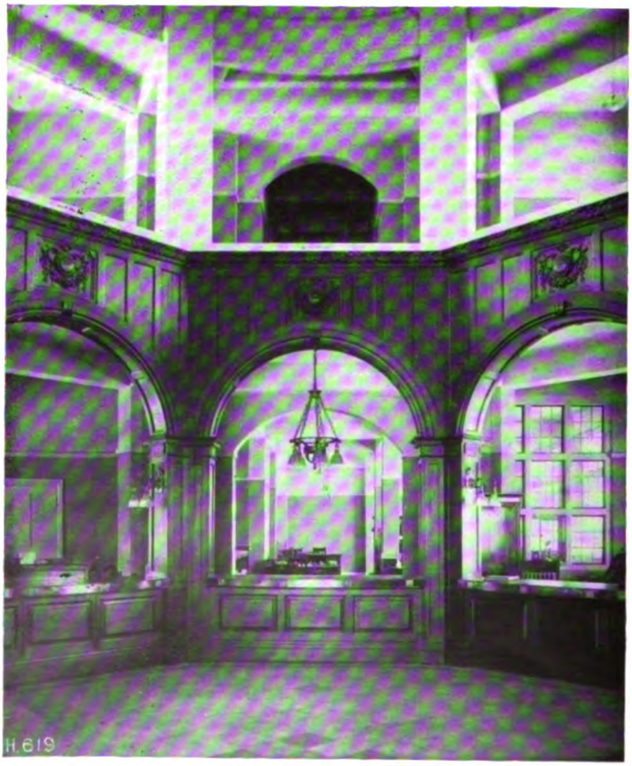
The carved entrance doors and beams are of teak, also the doors in the vestibule, all being filled in with copper glazing.

The panels, in pediments upon the three sides of the dome, are filled in with Carrara ware, executed by Messrs. Doulton & Co., each block being about 12 in. square and 4 in. thick, and secured with iron straps built into concrete; they represent old and modern shipping. All cornices and mouldings have been formed *in situ*.

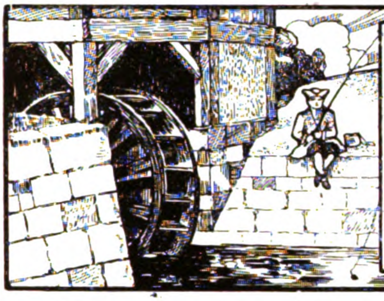
The whole of the interior walls are finished in plaster. The exterior mouldings were also formed *in situ*, and after the removal of the centering, the work was cleaned down and the whole given a finish to match artificial stone.

The building, including the demolition of the wrecked premises, took fifteen months to complete from the date of signing the contract in England, and great credit is due to the Empire Stone Co., of Thanet House, London, the contractors for this work, who, besides carrying out the reinforced concrete work, fixed all the material and fittings made by the various sub-contractors. All material was shipped by the Royal Mail Steam Packet Co., with the exception of matrix for cement and electric light installations, which was carried out by a Canadian firm.

The building was designed by Mr. Lionel U. Grace, A.R.I.B.A., London, and the Superintending Architect in Jamaica was Mr. Fuller Clark.



View of Booking Hall.
ROYAL MAIL OFFICES, KINGSTON, JAMAICA.



COMPRESSOL FOUNDATIONS.

In this article we give a description of the "Compressol" system of foundations for buildings in unstable ground, and which has been used with great success on the Continent for some years.—ED.

THE problem of providing suitable foundations for buildings and engineering structures in unstable ground is one that constantly comes before architects and engineers. Cases often arise where very heavy loads must be transmitted to limited areas, and any developments for providing foundations in such circumstances must be welcomed.

The system described in this article has been employed largely on the Continent and in various other parts of the world with great success. We refer to "Compressol," which has only recently been introduced into England, and which, as soon as its merits have been demonstrated, will undoubtedly have a considerable vogue here, as we are informed it can compete successfully in the matter of cost, which, combined with efficiency, is the ultimate factor to be considered. It has been used for every kind of bad ground and for all types of building construction.

The essential feature of "Compressol," as its name implies, is the compression of the soil by mechanical means. The apparatus employed is a special form of pile-driving machine (see *Fig.* 2). This operates heavy dies, which are dropped from any required height. The dies are three in number, and are of various shapes (see *Fig.* 1), and we give a brief description of their different functions. "P" shows what is termed the perforator, a heavy conical die, about 10 ft. long, weighing 43 cwt. This is employed for sinking the well, into which concrete is deposited in layers of about

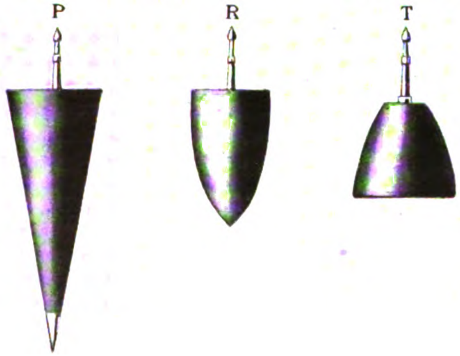


FIG. 1. COMPRESSOL DIES.

12 in., each layer being thoroughly rammed by a 2-ton rammer ("R"). This rammer is so formed as to drive the concrete laterally into the strata surrounding the well made by the perforator.

When it is mentioned that the perforator has a diameter of nearly 3 ft. at its top end, it will be readily understood what a considerable compression and consolidation of the strata takes place when this great weight is dropped from a height of 30 to 40 or even 50 ft.

The concrete employed is of a very low grade, only about 10 to 1; but, owing to the thorough ramming it receives, the concrete forming the pier is often superior to rich concrete like 3 to 1, such as is used in piles.

It should be mentioned that the perforator, which is of cast iron, with steel point, is fitted with a slot at its lower extremity, which picks up samples of whatever strata is penetrated, and thus furnishes a valuable guide to the operator. The top of the perforator is also provided with a cutting edge, which clears the cavity when the die is hauled up by the winch after each drop. The height of the drop is governed by a ring fixed at any desired point to the hoist tower. This ring engages the automatic coupling which grips the particular die in use; it will be noticed that each die has a stem, fitted with an acorn-shaped head, for this purpose.

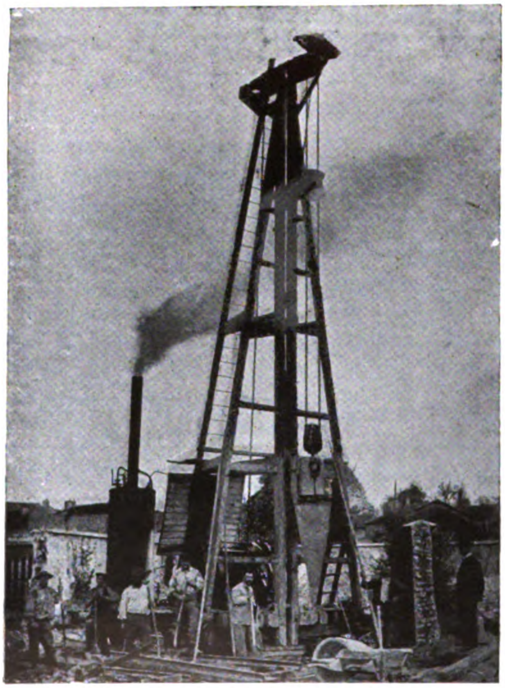


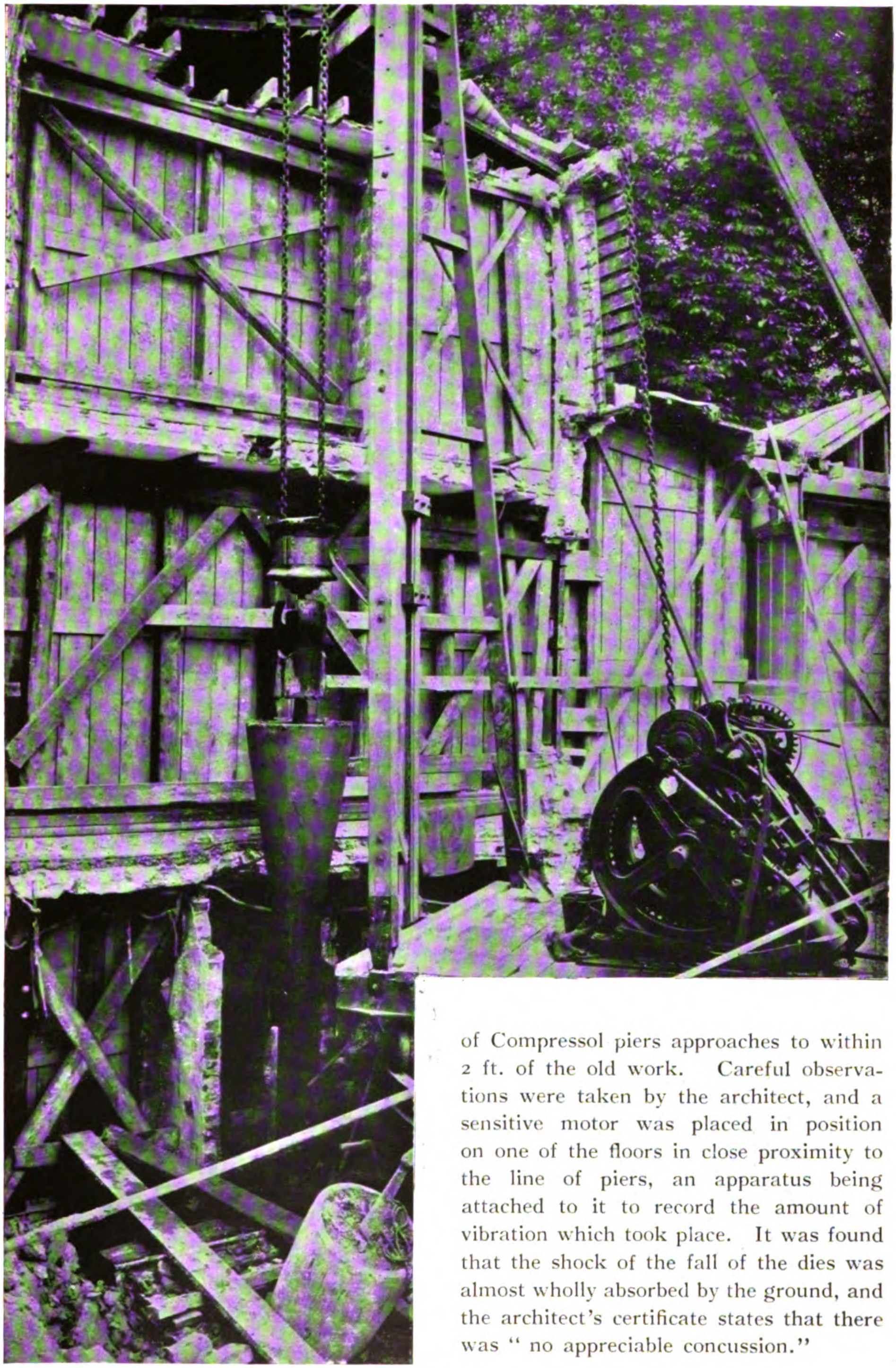
FIG. 2. DRIVING MACHINE.

The third die, the tester ("T") weighs 30 cwt., and is employed for finishing the ramming of the pier, and for testing its bearing capacity.

One of the chief advantages of this system, as compared with piles sunk in the ground by means of a steel tube, which is withdrawn as the concrete is deposited, is that continuity of section from top to bottom is guaranteed, and the danger of admixture of concrete and the surrounding strata is largely obviated. Further, the great section of the Compressol piers (4 to 6 ft.) provides ample margin for contingencies of this nature. It will be observed that the whole operation of constructing the piers is performed practically "in sight."

As compared with the straight line of a pile, it will be noted what a tremendous amount of skin friction is provided by the corrugated surface of the piers, due to the varying resistances of the different strata passed through. This, of course, greatly adds to the bearing capacity of the pier.

In cases where it would be dangerous to attempt pile driving, owing to the shock caused by the heavy drop of the monkey, Compressol can be employed with perfect safety. This adaptability of Compressol for situations adjacent to old buildings is clearly shown in *Fig.* 3. In this building (in the Avenue de Versailles, Paris) the line



of Compressol piers approaches to within 2 ft. of the old work. Careful observations were taken by the architect, and a sensitive motor was placed in position on one of the floors in close proximity to the line of piers, an apparatus being attached to it to record the amount of vibration which took place. It was found that the shock of the fall of the dies was almost wholly absorbed by the ground, and the architect's certificate states that there was "no appreciable concussion."

Showing piers being sunk within 2 ft. of old building.
FIG. 3 FOUNDATION WORK, AVENUE DE VERSAILLES, PARIS.

Two sizes of perforator are employed, the larger one, previously mentioned, being 2 ft. 9½ in. at its greatest diameter, whilst a smaller one, 2 ft. in diameter, is used for making smaller piers if required. The diameter of piers made by the small size die is approximately 3 ft., whilst the large die makes a pier about 4 ft. in diameter. It will be apparent, however, that the size of pier resulting is largely contingent on the

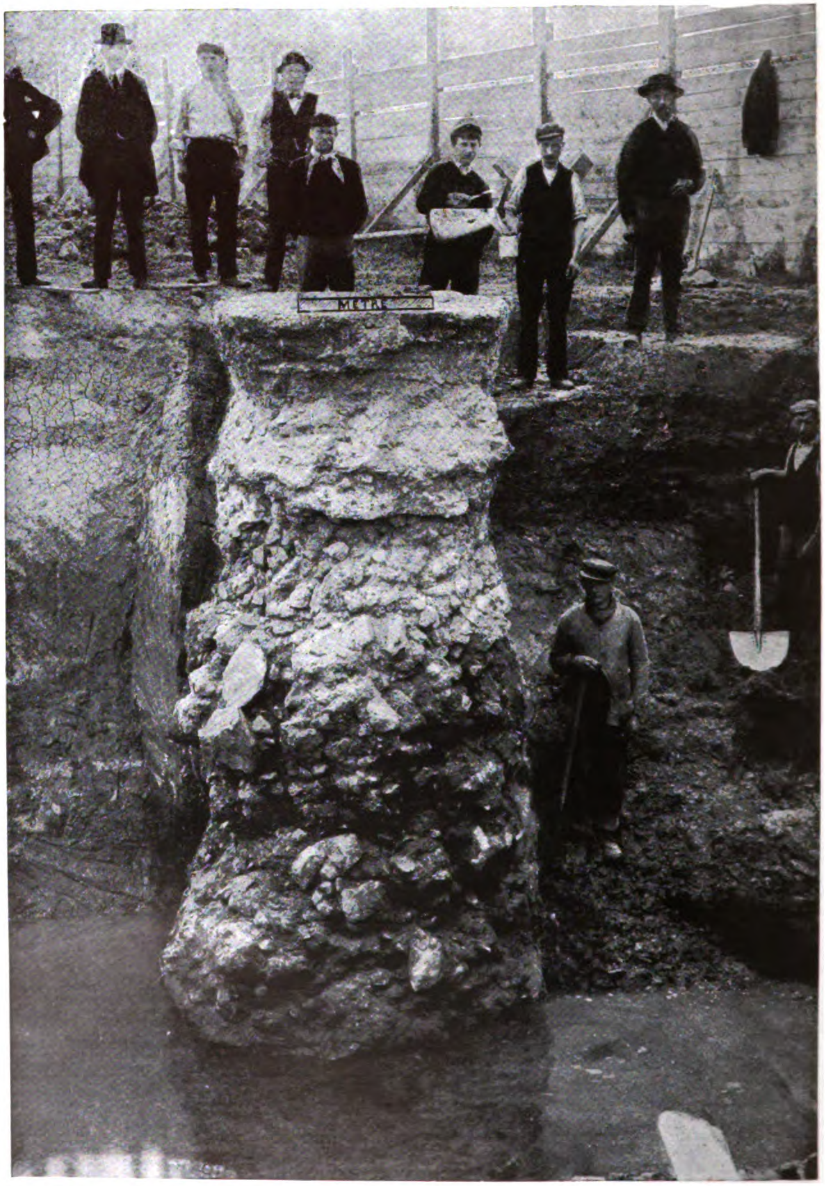
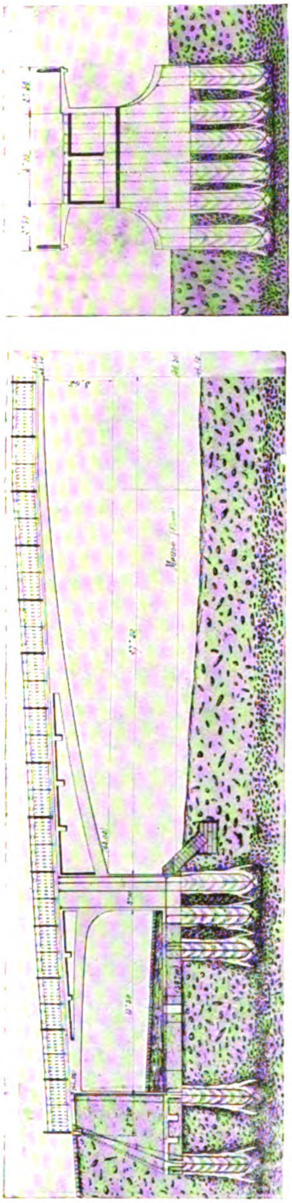


FIG. 4. ONE OF THE FOUNDATION PIERS FOR A FACTORY FOR MESSRS. LEVER BROTHERS.

nature of the ground penetrated, the concrete naturally spreading more in very soft strata.


Transverse section.

Longitudinal section.

FIG. 5. BRIDGE AT LIÈGE.

The large piers each carry a safe load of 120 to 125 tons.

Compressol piers have been sunk to a depth of 40 ft. and even more.

If it is merely desired to consolidate made ground to support a structure of comparatively small weight, it is sufficient to treat the surface by means of the rammer so as to form foundation trenches which are filled in with thoroughly rammed concrete, but in the case of aquiferous soil it becomes necessary to rely only upon the solid strata and to form well foundations.

An ingenious device is adopted where water-bearing strata or running sand are encountered. Clay is tipped into the hole as the work proceeds, the plastic material being forced against the walls by the blows of the perforator, with the result that the completed well is lined by a thoroughly consolidated plastic tube. Or, if preferred, the walls can be lined with concrete distributed and rammed in the same way as the clay.

If desired, reinforcement may be incorporated in the mass of the concrete and allowed to project above the top of the pier for anchorage into the reinforced concrete beams, slabs, or arches of the superstructure, which is thus moulded in monolithic connection with the foundations.

Fig. 4 is a photograph of one of the foundation piers for a factory for Messrs. Lever Bros., after the surrounding earth had been excavated, and gives a good idea of the form of a pier.

Fig. 5 shows the elevation and cross section of the Compressol foundations for a bridge of a total length of 260 ft. at Liège.

Fig. 6 shows a test carried out on the foundations of the Palace of the King of Siam, at Bankok. This palace is built on thick mud. The piers were sunk to a depth of 40 ft.

This system has been adopted by the French War Office and Admiralty, and by many public bodies and others in various parts of the world. It has been used in Egypt for some years, and in *Fig.* 7 we show the piers being sunk for the docks and magazines at Alexandria.

The number of buildings in which Compressol foundations have been used extends to upwards of two hundred. This system has, therefore, been well tried and there is nothing experimental in its adoption.

This system of foundations is being introduced into this country by Compressol, Ltd., of 8 Old Jewry, London, E.C.

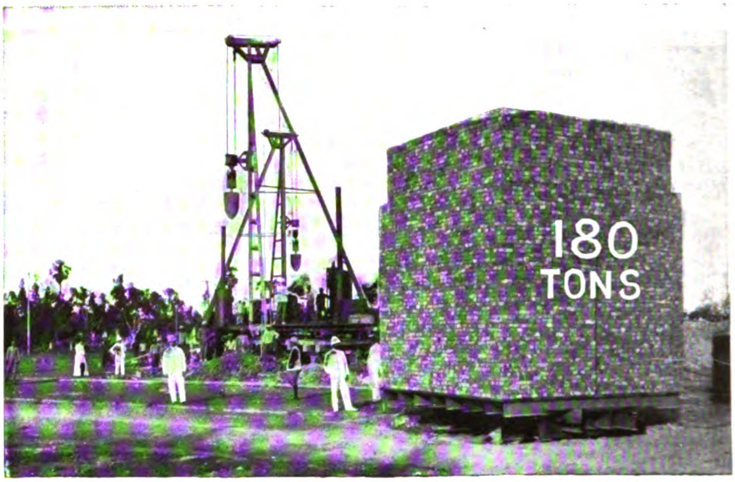


FIG. 6. TEST ON FOUNDATIONS OF PALACE AT BANKOK.

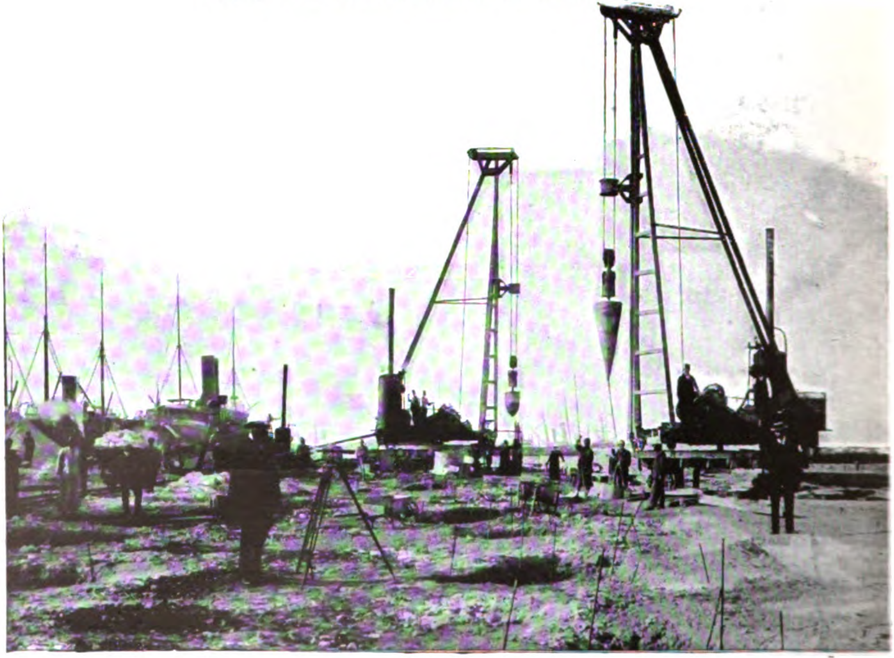
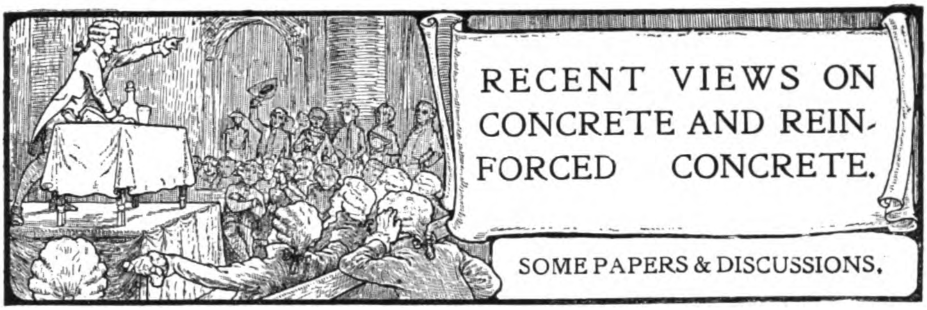


FIG. 7. PIERS BEING SUNK FOR DOCKS AND MAGAZINES, ALEXANDRIA.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.

CONCRETE BRIDGES AS A SPECIALTY.

Paper by DANIEL B. LUTEN, Indianapolis, Ind.

"Concrete Bridges as a Specialty" formed the subject of a Paper recently read before the American Society of Engineering Contractors, by Mr. Daniel B. Luten, and was published in Vol. II. of the Journal of that Society.

THE rapid development in the use of concrete for bridges in the past five years has attracted to this line of construction numerous contractors and engineers. After the erection of a small concrete bridge in the country, on which the contractor must, of necessity, employ as labourers some of the farmers living in the vicinity, it is no unusual thing to find that each of these farmers has become imbued with the idea that the construction of a concrete bridge is a matter of extreme simplicity, and that he himself is better qualified to do the work than the contractor. And at the next tender for such a bridge some of these farmers appear as bidders, although they have no actual knowledge of costs or methods. Add to this the fact that every grading contractor, every sidewalk builder, and every general contractor, looks upon concrete bridges as a legitimate field of operation, and bids upon them as opportunity offers, and it will be readily understood that an abundance of competition is already provided for every concrete bridge that is let. The conditions are not improved by the further fact that the concrete bridge is superseding the steel bridge, and that contractors who formerly confined themselves to steel construction are now compelled to enter the concrete field, thus adding to the existing overcrowded competition which already had made of steel bridge building a rather unprofitable undertaking.

The conditions that make competition severe among contractors on concrete bridges apply also to engineers who design such structures, more especially on public improvements. Almost every county and city engineer, no matter what his previous training, instead of enlisting the help of the specialist, as he would in constructing a steam roller, or a sewer system, considers himself fully competent to design, and superintend the building of, a concrete bridge. This attitude on the part of engineers is to some extent due to the fact that steel bridge designing has become a comparatively well-known science, now taught to every undergraduate, and it is generally supposed that concrete bridges will submit to the same treatment; but there is a wide difference. A steel bridge endures for only a few years, and depends at best almost entirely upon its utility for its beauty. But a concrete bridge, once built, is built for all time. The structure that to-day appears beautiful to its amateur designer or constructor, may in fifty years become an eye-sore to the community.

Design. — Concrete bridges in their most efficient form are by no means the simple structures to design and erect that they are supposed to be. As an illustration of how experts may disagree on the theory of concrete bridges, we have one group of experts asserting that a reinforced concrete arch should have an amount of reinforcing metal proportional to its crown thickness. The rule as frequently expressed is, one per cent. of the crown area should be metal. A recent textbook recommends that the line of thrust be kept within the middle third, and *all* reinforcement eliminated, citing as proof the fact that the largest concrete bridges, with span of upwards of two hundred (200) feet, have no reinforcement. Yet in both cases the experts are mistaken. Reinforcing metal should be used in arches to resist tensile stresses. A properly designed, efficient arch will have no tensile stresses under the fixed loading, since the arch can be proportioned so that it will be in equilibrium under that loading. The necessity for reinforcement, therefore, depends largely upon the moving load. But as the span increases, the weight of the bridge itself increases, and the moving load becomes relatively unimportant on a long span. Hence, theoretically, the longer the span, the *less* the reinforcement required, and a concrete arch of very long span may well be built with no reinforcement whatever. Instead of the reinforcement bearing a constant ratio of one per cent. of the crown area, quite the contrary is the case, and the reinforcement will theoretically become less as the crown becomes thicker. Thus both of the expert theories quoted, and very generally accepted, may be seen to be in error.

Obviously, then, there is a field for the expert in concrete bridge design, as well as in concrete bridge erection. But as a speciality for engineers or contractors, the concrete bridge business is not at present in a condition to offer anything very attractive to the engineer or contractor. As in every other line of concrete construction, to improve conditions contractors are needed who are skilled in the art of concrete construction and have a knowledge of the underlying engineering principles—in short, engineering-contractors. But how can engineers or contractors acquire skill in this line, when any unskilled engineer or contractor can secure the business at cut rates or even actual loss, lack of knowledge and experience being overcome in many cases by local acquaintance or influence. There is no denying the fact that, on public work especially, the local engineer and the local contractor are most influential in determining who shall design and build their bridges, even though they may not be specialists in bridge building.

If the local engineer is a broad-gauge man he will, of course, call for the help of the specialist. But the local contractor rarely gives way to the bridge specialist. He makes the experiment of building one or two structures himself, and then gives way to another and still another of his kind.

There are to-day not more than a dozen contractors in the United States actually making a speciality of concrete bridges for public improvements. Hundreds have built one or two bridges, and lost enough in each case to discourage a repetition of the experiment. There are no contractors in concrete bridge building to-day that have continued successfully in the business as a speciality for five years. Hundreds have pursued the business with energy for a year and then dropped it to undertake something more profitable. There are hardly a dozen engineers in the United States who have designed more than ten concrete bridges for public highways. Hundreds have designed one or two apiece, and, having found that the finished structure did not conform to their mind's ideal, have discontinued the work.

Necessity for Specialisation.—In a business of this kind, where plans are advertised for public tender, and where any inexperienced bidder has an advantage over the specialist, the remedy must be in greater specialisation. The remedy is simple in theory, but very difficult of application. Contractors who lack experience should refrain from bidding until they can remedy their inexperience. Or, if they prefer to gain experience by actual construction, should confine themselves to small structures and small contracts at first, and even then be prepared to sacrifice profits until they acquire a reputation for artistic workmanship. The general public must sometime realise that the contractor or engineer of wide experience in the building of concrete bridges is the one on whom to rely to secure satisfactory structures. In time the people will demand such training and experience, regardless of cost.

Engineers can assist greatly in bringing about better conditions in concrete bridge construction by drawing the most rigorous specifications and compelling their execution. Engineers ought to be examined before a State Board and licensed. It might be of advantage also to license contractors to build highway bridges, requiring a certain amount of experience together with a license fee of sufficient amount to eliminate the occasional bidder. Contractors may improve conditions by calling to their aid experienced engineers or builders, and if they hope to better their calling they should publish their losses truthfully, but suppress their profits.

Contractors' Records.—Contractors should, of course, keep complete cost records, showing the distribution of cost against the separate items that go to make up the structure; and such cost records should show the complete cost to date at regular and frequent intervals—*i.e.*, daily or semi-weekly. The contractor should be able at any time to turn to his records and quickly ascertain the cost on each separate item of construction. Such a cost record is essential to a proper understanding of the cost of the structure, is valuable in determining the rating of the foreman in charge, and is the only safe basis for determining bids on future work.

The contractor who thus estimates his work safely, uses an estimate sheet as follows, in which each and every item that goes to make up the cost of a highway bridge is included :

ESTIMATE.

Right of Way			
Temporary Bridge			
Removing Old Bridge			
Excavation—Yards Wet ______			
Yards Dry ______			
Cofferdams			
Sheeting and Shoring			
Piling			
Falsework Piling			
Steel ______ Lbs. @ ______			
Placing @ ______			
Lumber ______ Bd. Ft. @			
Erection			
Concrete ______ Bbls. Cement			
______ Yds. Gravel			
______ Yds. Stone			
______ Yds. Sand...			
Labour, Mixing and Placing			
Waterproofing			
Filling ______ Yds. @ ______			
Drains, Conduits, etc.			
Paving ______ Sq. Yds. @			
Sidewalks ______ Sq. Ft. @			
Curbs ______ Lin. Ft. @			
Railing ______ Lin. Ft. @ ______			
Lamps and Wiring			
Removal of Centering			
Superintendence			
Bond, Insurance, etc.			
Moving Plant, etc.			
Total Field Cost			

What each of the items represents in actual cost is known only to the experienced contractor and cannot be given here because it would be of local value only and would be found misleading for any other field. But even the novice in estimating will come far nearer the truth by making a guess for each item and then taking the total than if he bases his price on the yardage of concrete alone.

Estimates. — There is a popular notion also that the cost of a concrete bridge may be estimated roughly by multiplying the span in feet by the width of roadway by two dollars. In other words, that the cost approximates $2.00 per sq. ft. of roadway projected on the span. But this is a dangerous rule, because it gives only the lowest approximate cost for very favourable conditions, and may vary several hundred per cent. The height of the bridge from bed of stream to roadway affects the cost quite as appreciably as the span or roadway. Yet the above rule-of-thumb makes no allowance for height or for numerous other elements that go to make up the cost of the bridge and which vary from place to place. The only safe way to give an estimate on a concrete bridge is to draw it to scale, compute its contents, and then follow the estimate sheet. The contractor who has made a speciality of concrete bridge erection can usually approximate the cost of a proposed bridge by its similarity to some other bridge which he has erected and of which he recalls the details of cost. There is no other safe way.

Foreman's Report.—The foreman in charge is required to send to the office at frequent and regular intervals, say nightly or semi-weekly, a complete, distributed statement of all costs incurred on the work since his last report. This statement of cost is for materials actually delivered on the work to be used in the structure, and for indebtedness incurred for labour, freight, supervision, sundries of any kind whatever actually delivered to the foreman. Each report should have the total cost to date carried forward.

Upon receipt of this ledger at the office the totals of each column should be transferred to the cost ledger. A glance at the last sum entered in each column will show the total expenditure for that item to the date of the last report, and thus a statement of cost may be kept complete to within two or three days, regardless of whether materials are purchased by the office or the foreman, and whether on credit or for cash. The estimated cost of each item should be entered at the extreme foot of each column in red ink. A comparison of the last entry with the estimated cost at the foot of the column will show when an item exceeds its estimate. And since the items in a bridge are usually completed consecutively, a danger signal is thus provided calling attention to this contract.

A careful following of the cost ledger with the occasional visits to the bridge will enable the contractor or field superintendent to determine whether or not the foreman is handling the work properly.

While the foreman should be encouraged to keep a record of the total cost, and should be expected to become thoroughly informed as to the cost of the various items, yet he should not be permitted to have access to the detailed estimate or to the contract price. The foreman is supposed to build a concrete bridge for the contractor, who is making a speciality of concrete bridges, at the lowest possible cost consistent with good workmanship. He should not be permitted to know, at least not until after completion, whether the contract results in a profit or a loss. He should be given to understand what quality of workmanship is desired, and then should be encouraged to maintain that at the lowest possible cost; but he should not be swerved from his purpose by possible gain or loss.

Guarantee against Failure.—One other powerful influence can be brought to bear by bridge specialists to make the building of concrete bridges what it ought to be, a speciality beyond the reach of the amateur, and that is a guarantee backed by a surety company bond. Each engineer who gives an estimate on the cost of a concrete bridge should be required to give bond that the bridge can be let within that estimate. A law to this effect is now in force in California and is producing excellent results. Each contractor who undertakes to build a concrete bridge should be required to give bond in the amount of the contract guaranteeing the bridge against failure for a period of at least one year from completion. Such a guarantee is more effective than inspection in securing good work, and in case of failure of the structure, the innocent purchaser is protected and not left to determine the question of whether the engineer who designed the structure, or the contractor who built it, was at fault. Requirements of guarantees on street pavements or other temporary improvements in which large maintenance charges are involved, may be of doubtful propriety; but a concrete bridge is a permanent improvement, and if properly erected should require no repairs. In such a case the guarantee bond is only an evidence of the faith that every contractor should have in the structure he undertakes to build. An engineer who designs a bridge, but does not inspect it, cannot of course be expected to guarantee the structure, for he has no control over the materials or workmanship, both of which are essential elements of its success. If the engineer who designs the structure also exercises absolute control over its materials and workmanship, he should have no hesitancy in giving a guarantee bond provided he is financially able to do so. But the contractor can offer no excuse in either case for refusing to guarantee his work, for if he does not approve the design he should not submit a bid for it. Otherwise he can hardly claim the title of engineering contractor.

LONDON COUNTY COUNCIL SCHOOL OF BUILDING.

THE HISTORY AND DEVELOPMENT OF REINFORCED CONCRETE.

A Lecture by Mr. H. KEMPTON DYSON.

Introductory to a course of about sixty lectures on Reinforced Concrete, which is to be given this session at the London County Council School of Building, Ferndale Road, Brixton, S.W., by Mr. H. Kempton Dyson, Secretary of the Concrete Institute, a special free public lecture on " The History and Development of Reinforced Concrete " was delivered on Tuesday, September 27th, of which the following is a summary.

First Known Examples of Reinforced Concrete.—It is only within recent years—namely, about the last twelve years—that reinforced concrete as a method of construction has come into prominence. The subject, however, is not entirely new, because it is over fifty years since attention began to be directed by inventors thereto, and, indeed, reinforced concrete of a kind has been done for ages almost. The Romans and others reinforced concrete by bronze rods, timber and tiles.

The first suggestion of an idea of reinforcing concrete, in modern times, seems to have been a statement in J. C. Loudon's " Encyclopædia of Cottage, Farm and Village Architecture," published in 1830, in which it was suggested that flat roofs might be constructed of a latticework of iron tie rods thickly embedded in cement and cased with flat tiles. In 1840, about, two systems of floor construction were employed in Paris, known as the Vaux and Thuasné systems; the former consisted of round rods, closely spaced, hooked over flat wrought-iron bars placed on edge some distance apart, and embedded in a slab of plaster of Paris concrete; while the latter employed small iron joists, with hangers or stirrups placed over them in which round rods were suspended, placed in holes in the stirrups. Plaster of Paris was, however, not a proper cement to be employed, as it caused the embedded iron to rust, and probably the reason reinforced concrete did not arrive sooner was that the world was waiting for a suitable cement for making concrete—it needed Portland cement, which was invented in 1824, but was not manufactured to any extent until some years later.

Pioneers of the Reinforced Concrete Industry.— The first real inventor of reinforced concrete in the modern sense seems to have been W. B. Wilkinson, a plasterer, of Newcastle-on-Tyne, who took out a patent in 1855 for reinforcing slabs with a network of iron rods, and a M. Lambot, another French contractor, proposed the construction of ships by means of concrete, with an embedded skeleton of wire, and he constructed a punt of the kind which was shown at the Paris Exhibition of 1853, and is still in service in a pond at Miraval, where he resided. The development of the subject was extended by the following inventors : C. C. Dennett (1857), Matthew Allen (1862), Frederick Ransome (1865), H. Y. D. Scott (1867), Philip Brannon (1870), who first suggested the driving of reinforced concrete piles; Monier (1867-1873), Thaddeus Hyatt (1873-1877), who conducted a great many tests on reinforced concrete beams and showed how to make calculations for determining their strength; W. E. Ward (1875), W. H. Lascelles (1877), H. J. Jackson (1877), E. L. Ransome (1884), J. C. Golding (1884), W. H. Lindsay (1885), William Simmons (1885-1886), who designed the block of offices, No. 63, Lincoln's Inn Fields, London, which, constructed of reinforced concrete, is still in use and in excellent condition; Lee & Hodgson (1885), who invented a spirally reinforced concrete column; Bordenave (1887), Cottançin (1884), W. H. Briggs (1889), J. Mayoh (1890), A. J. B. Ward (1891), C. A. Day (1891), Franz P. Meyenberg (1891), who introduced the first loose stirrups in beams; F. G. Edwards (1891), P. Stuart (1892), Koenen and Wayss (1892), François Hennebique (1892). There are over seventy systems upon the market in Europe and America to-day.

Uses of Reinforced Concrete.—Reinforced concrete is now used for the following: Beam slabs, cantilevers, arches, columns, piles, pipes, masts, telegraph, tramway and electric-light poles and standards, reservoirs, barges, boats, punts, pontoons, caissons and ordinary walls, retaining walls, fences and fence posts, clothes' posts, hitching posts, paths and pavements, cowhouses, piggeries, greenhouses, sheds, warehouses, offices, churches, houses, etc., silos, railway sleepers, chimney shafts, sea protection and groynes, tables, window-frames, safes, strong rooms, garden seats, cabinets and other furniture—even tombstones and coffins.

NEW WORKS IN CONCRETE
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

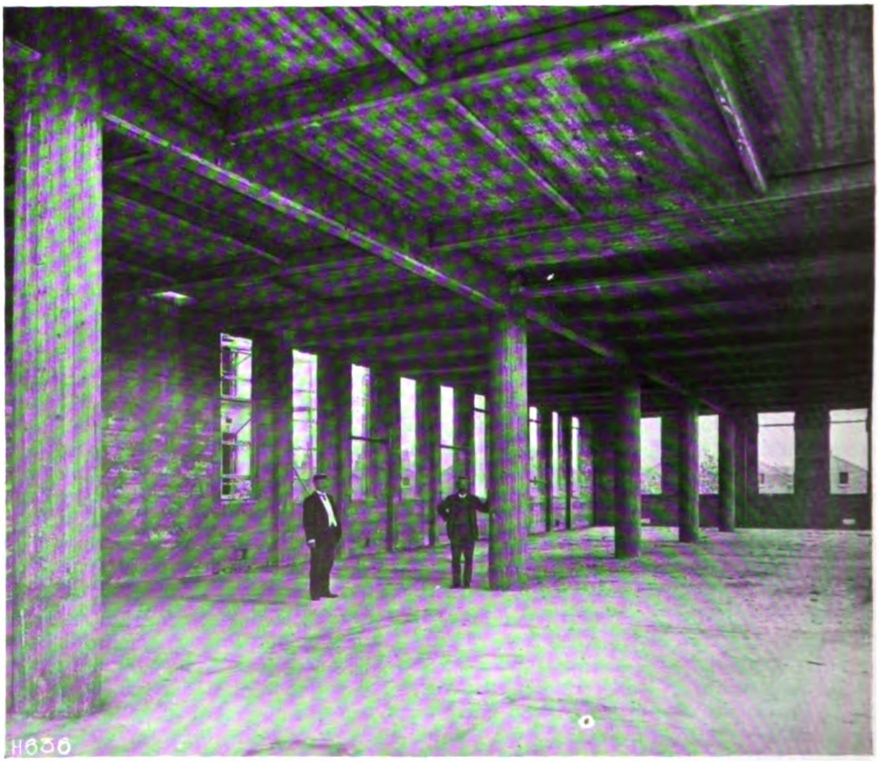
THE NEW MONEY ORDER OFFICES, HOLLOWAY.

THIS extensive building, which we have previously described in our April and June numbers, is now completed, as far as the reinforced concrete portion of the work is concerned.

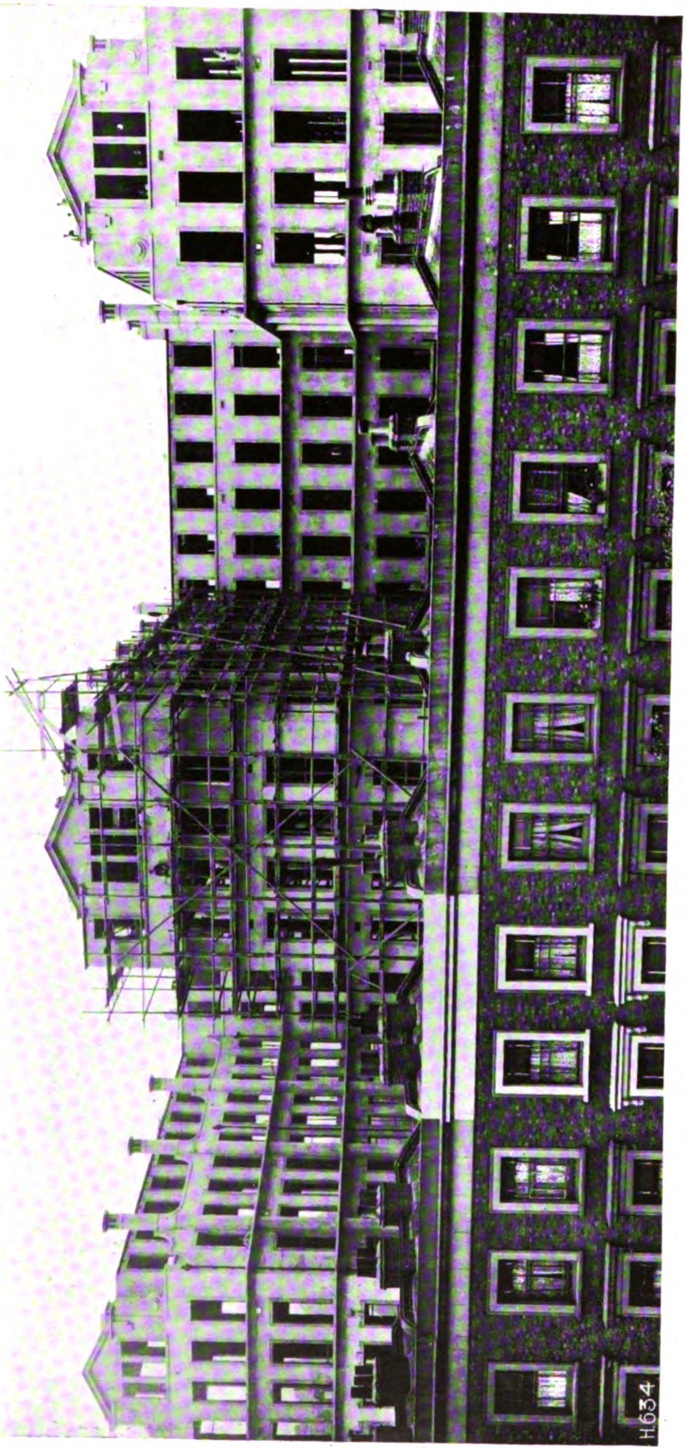
The entire structure has been executed on the Coignet system for H.M. Office of Works.

Messrs. William King & Son, contractors for the work and licensees of the Coignet system, began the concreting operations about the middle of the month of December last, and the building was practically completed about the end of July, or, in other words, this extensive building was erected in about eight months' time, and we are informed that the contractors were well within the time specified for the execution of the work. The rapidity with which this contract was executed should go far to prove that reinforced concrete structures can be erected more quickly than in steelwork.

In order to fully realise what has been achieved in this respect by the contractors, with the help of Messrs. Edmond Coignet, Ltd., who have supplied all the working



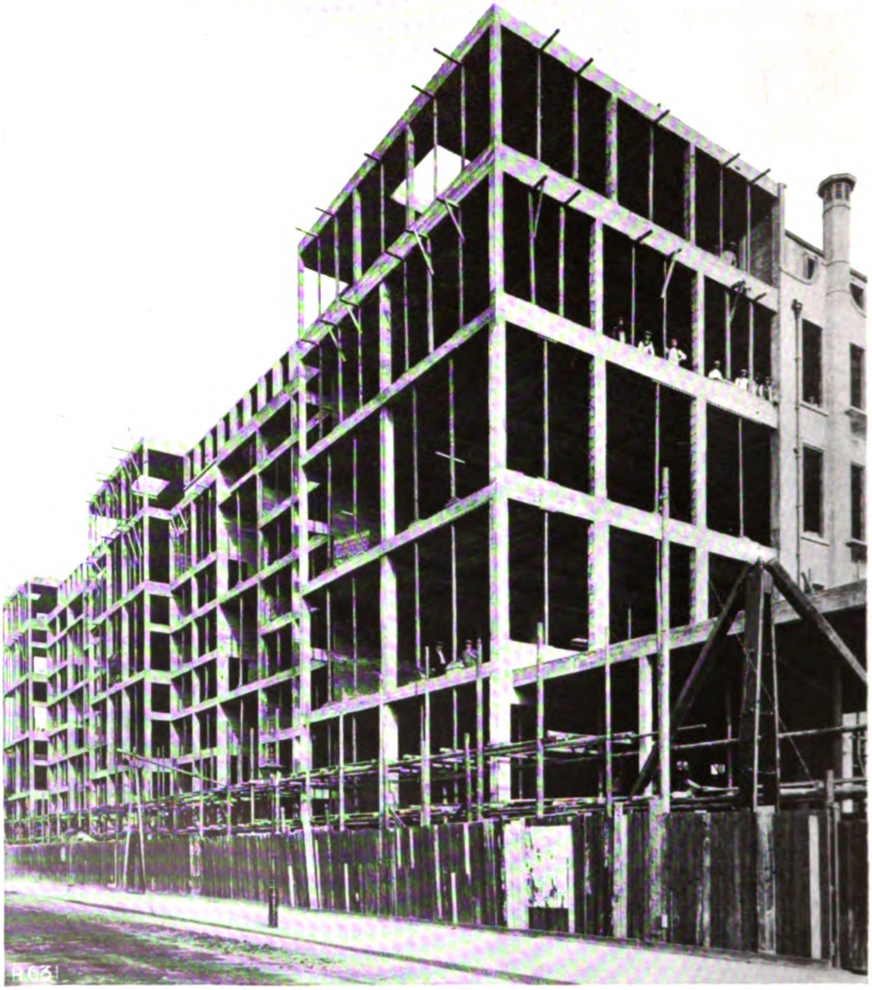
View of first floor of one of the wings.
THE NEW MONEY ORDER OFFICE, HOLLOWAY.



Back elevation, showing the reinforced concrete walls.
THE NEW MONEY ORDER OFFICE, HOLLOWAY.

drawings, it is necessary to remember that not only did this work include about two and a half acres of flooring and roofing and a very considerable number of pillars complete with their foundation, but all the walls and partitions of this building are in reinforced concrete with the exception only of the front wall, which is to form the object of a separate contract, and which we understand is to be erected in brick and masonry work.

At the back of the building a large boiler-house has been constructed almost entirely buried in the ground, and the special nature of the ground has necessitated the introduction of strong retaining walls.



Front elevation in reinforced concrete, ready to receive the masonry walls.
THE NEW MONEY ORDER OFFICE, HOLLOWAY.

A long underground gallery, about a couple of hundred feet long, connects the boiler-house with the three wings of the building, which is in the shape of a letter "E." An underground tank has also been erected in reinforced concrete at the back of this building.

All the staircases, ventilation shafts, balconies, etc., are in reinforced concrete.

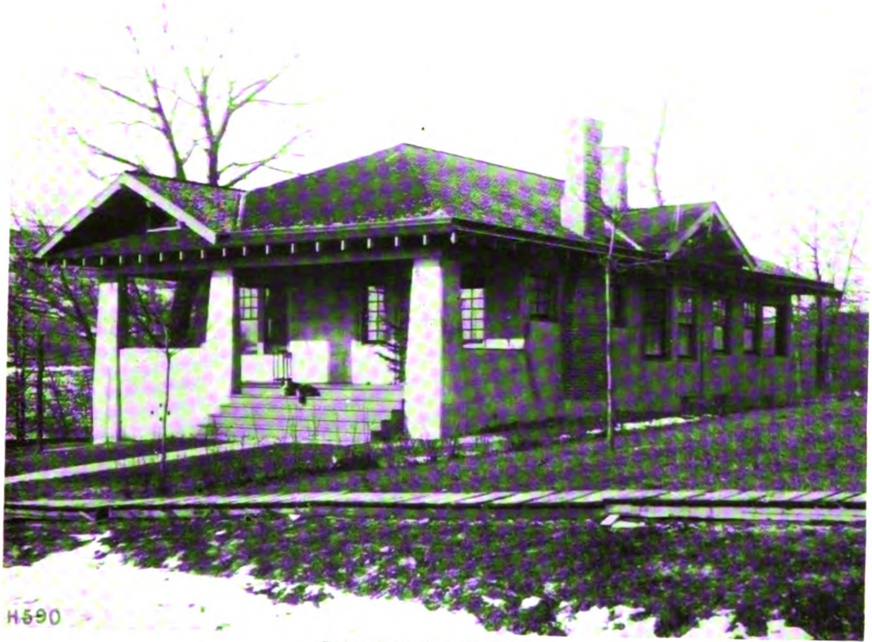
Various portions of the floors have been tested by application of a load, 50 per cent. in excess of the specified superload, and we are informed that the results obtained have been fully satisfactory in every case.

The cement being used in this work is the "Ferrocrete" brand supplied by the Associated Portland Cement Manufacturers (1900) Ltd.

REINFORCED CONCRETE BUNGALOWS.

REINFORCED CONCRETE is admirably adapted for use in small houses, but its adoption for this purpose has been comparatively slow, especially in this country. Our readers will, therefore, be interested in the following account of a number of bungalows built of reinforced concrete, which present a very pleasing appearance and which were erected very economically.

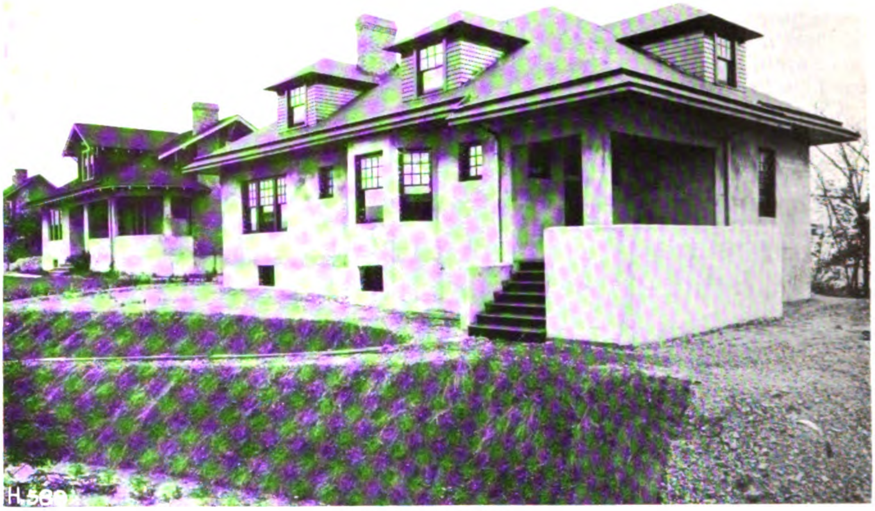
These bungalows were built at Carnegie, a suburb of Pittsburg. They were designed by Mr. W. H. Parrish, of Rosslyn Farms, Carnegie, Pa., U.S.A., and have proved very satisfactory. Concrete makes an absolutely dry and warm house, and the reinforcement makes a complete bond of the frame and the concrete; the result is a perfectly rigid house.



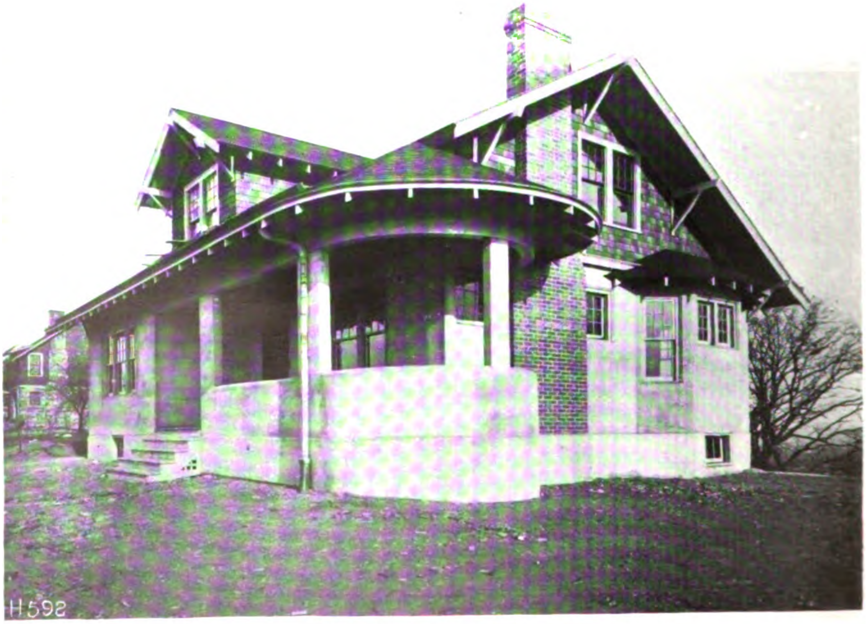
Baker Bungalow, Carnegie.
REINFORCED CONCRETE BUNGALOWS, CARNEGIE, PA., U.S.A.

Each bungalow contains five large rooms and bathroom on the ground floor and two rooms on the first floor.

The cellar walls are 8 in. thick, of monolithic concrete; a 4 in. plate is laid flush with the inner side of this wall, upon which the joists have a 4 in. bearing; another 2 in. by 4 in. plate is laid upon and spiked to the joist, and upon this plate the studding (2 in. by 4 in.) is placed 16 in. on centre. Between these studs is placed a form, 1½ in. thick, flush with the inside of the studs, and held in place by 1 in. strips at the top, middle and bottom of the studding. These forms are removed when the concrete has set, leaving a 1½-in. air space between the concrete and the lath and plaster, which is ultimately placed on the studs. A space of 2½ in. is thus left between the inside form and the outer edge of the studding,



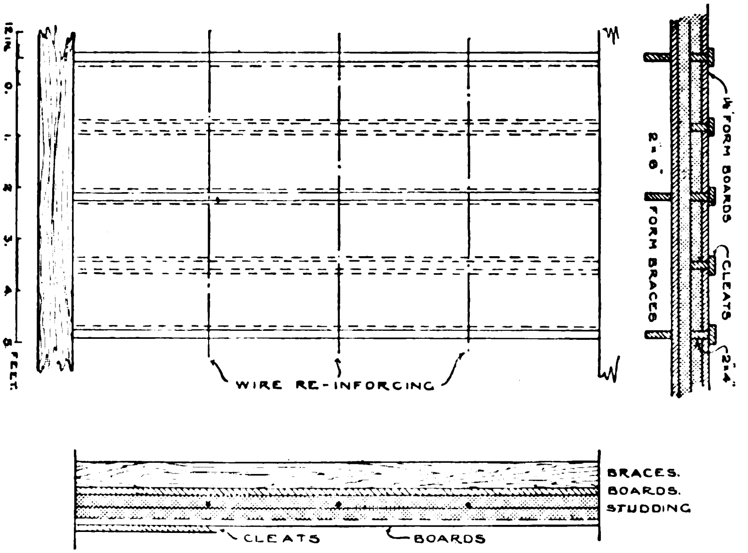
Bungalows at Carnegie.



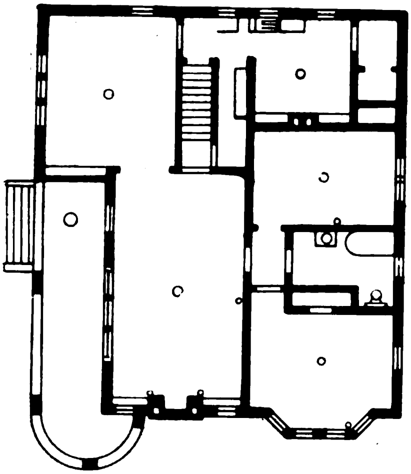
Harris Bungalow, Carnegie.

Reinforced Concrete Bungalows, Carnegie, Pa., U.S.A.

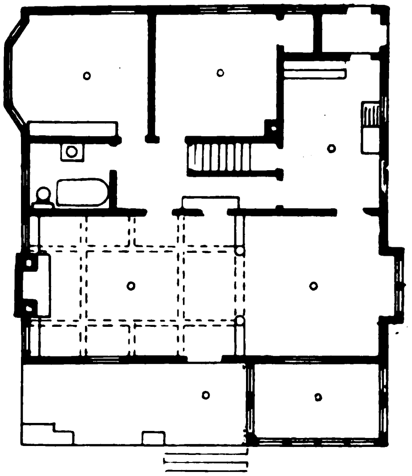
and there is a space of 4 inches on the cellar wall between the outer edge of the 2-in. by 4-in. frame and the outer edge of the cellar wall. An inch form is rested on the cellar wall, held in place by a 2-in by 6-in. timber placed opposite each studding and held in place by a wire which passes around the studding and is held 3 in. from the studding by a spacing block, which is removed as the concrete is put in. This makes a wall 2½ in. between and 3 in. outside of the studding, or 5½ in. thick,



Showing method of building and reinforcing walls.



First floor plan, Harris Bungalow.



First floor plan, Baker Bungalow.

Reinforced Concrete Bungalows, Carnegie, Pa., U.S.A.

which gives a wall of a total thickness, including the plaster on the inside and the outside, of 8 in.

The outside wall is plastered after the forms have been removed. In order to prevent cracking an angle iron 2 in. by 2 in. should be placed over each opening, as the wood frames are not rigid. A No. 9 gauge galvanized wire is passed entirely around the house and stapled to each stud, one below the windows, one half-way up, and one above the windows, thus embedding the wire in the centre of the concrete.

The concrete is mixed in proportion of one cement, three sand, and six machine slag, and all the water that it will carry. The plaster used on the outside is in proportion of one cement and two of sand, with sufficient lime putty to render it plastic and readily trowelled.

The window and door frames are fitted in position before the forms are placed, and great care is exercised to see that every space is filled with concrete.

The later houses are being constructed with concrete chimneys, with terra-cotta flue linings, which is found to be much cheaper and better than brick. These houses are heated with hot air furnaces at a cost not to exceed £5 per year.

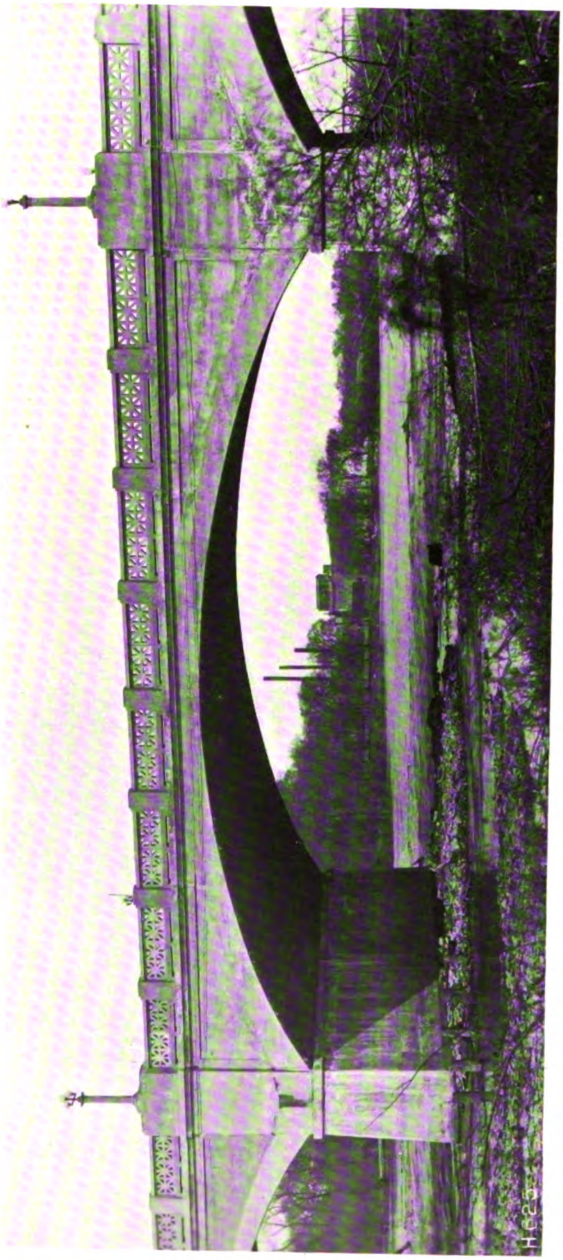
Reinforced Concrete Bungalow, Carnegie Pa., U.S.A.

The cost of construction was little more than for a first-class frame house.

REINFORCED CONCRETE BRIDGE AT CEDAR RAPIDS, IOWA, U.S.A.

Reinforced concrete for bridge construction, especially where the conditions permit of an arched structure, seems to be steadily ousting steel from its position, and it would seem as if the steel highway bridge is doomed to disappear within a comparatively short period of years. It can hardly be otherwise when due consideration is given to the great possibilities for ornamental treatment, combined with absolute safety and a practically unlimited life at negligible maintenance cost which can be ensured by the use of reinforced concrete.

At Cedar Rapids, Iowa, an old steel truss bridge of five spans, on steel masonry piers, is being replaced by a reinforced concrete structure of seven arched spans, one arch being shown in the illustration on p. 773. The new bridge is 605 ft. long from face to face abutments, and is 41 ft. 4 in. wide over all at the roadway, and 49 ft. wide over the ends of the piers. It carries a 28-ft. roadway and two 5-ft. wide footpaths.



Reinforced Concrete Bridge at Cedar Rapids, Iowa, U.S.A.

The seven arches are all of 80 ft. span and 10 ft. rise. The intrados is a three-centered curve, the radius being 40 ft. 3 in. in the arc between the springing line, and a point 8 ft. in front of the pier faces, and 90 ft. in the middle arc over the remaining 64 ft. of the span. The extrados is described on a radius of 108 ft. The thickness of the arch ring at the crown is 18 in. The arch reinforcement consists of an upper and lower set of 1⅛-in. round bars, spaced 1 ft. on centres, and banded in groups of four by ½-in. round stirrups passing round two bottom bars and then upward to fasten their ends on the two bars directly above. These stirrups are spaced 2 ft. on centres. The groups of bars are bound together transversely by ¾-in. round bars in the extrados extending across the entire width of the arch above each set of stirrups, that is 2 ft. on centres. In addition to this steel, there is a set of ¾-in. round rods extending from the body of the pier 17 ft. up into the haunches, in the extrados only, between the 1⅛-in. rods. They are anchored in the pier concrete by steel plates 5 in. square and 1 in. thick, threaded on their ends.

Between the arch rings and the bridge floor are four reinforced spandrel walls. Two of these are the usual face walls, while the other two are interior walls on the curb lines of the roadway. These walls are 4 in. thick. The bridge rails are of manufactured concrete stone laid in place on the bridge.

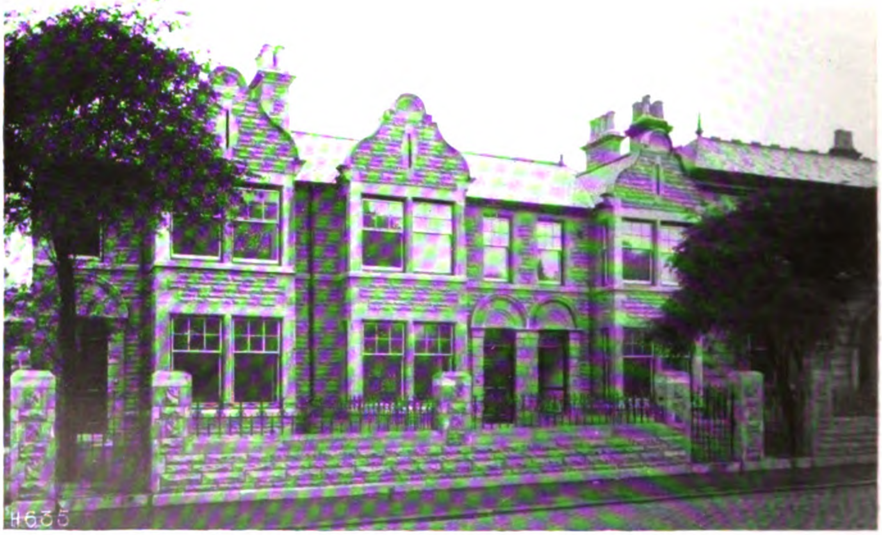
The expansion joints in the floor and spandrel walls are ½ in. wide. They are filled with six thicknesses of corrugated asbestos board, protected at the top by a ⅛-in. lead plate, folded into the joint to form a trough, and then coated with asphaltic material. A strip of asbestos board is also placed between the arch rings and base on the outer spandrel walls.

A waterproofing coat is placed on the top of the arches and piers before the road fill is made. This consists of a heavy coat of a compound cement of 1 part cement, ½ part slaked lime, and 3 parts sand. When this material is hard, it is heavily coated with a cement grout. The floor of the bridge is drained into catch-basins, delivering to 4-in. drains placed in each pier.

The arch ring concrete is placed over half of the width of the span in one day and over the other half the next day. The arch and spandrel wall concrete is mixed 1 : 2 : 4, using crushed stone up to 1½-in. ring. The upper 18 in. of the inner spandrel walls and the sidewalks are made of a 1 : 3 mixture, using river gravel. Marquette Portland cement is being used on the work.

The bridge will cost approximately $69,000 (£13,800).

Mr. Ira G. Hedrick, of Kansas City, is consulting engineer and designer of the bridge. Mr. W. A. Hoyt is engineer in charge for the Union Engineering and Construction Company.



CONCRETE BLOCK HOUSES AT STOCKTON-ON-TEES.

CONCRETE BLOCK HOUSES AT STOCKTON-ON-TEES.

THE houses in Bowesfield Lane, Stockton, shown in the illustration on this page are built with rock-face concrete stone building blocks, 4½ in. thick. They each have a 20-ft. frontage, with large square bay windows to ground and first floor. The dwarf walls in the front are built with 9-in. rock-face hollow concrete blocks. All the blocks were made with the Dring patent building block machine supplied by the Stockton Stone and Concrete Co., Ltd., of Norton, near Stockton-on-Tees.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

CEMENT AND CONCRETE FOR ORNAMENTAL WORK.

CEMENT and concrete for ornamental work has no equal where permanence and durability as well as utility are considered, and its application even to-day gives but a faint conception as to its possibilities in the near future. Its use in retaining walls, bridges, steps, balustrades, columns, and pergolas is now general.

The embellishment of buildings by cement stone has become, through the high standard of excellence attained, a favourite method for artistic work by architects in America, and is now being executed on many private estates. The landscape-architect's work is being harmoniously emphasised by pergolas with cement columns, winding stairways, ornamental railings of moulded cement, artistically tooled cement urns, cement-lined pools and formal walks. It has been shown possible to execute any scheme of garden ornamentation in artificial stone with results in complete harmony with the ideas of the designer, and the cost is such as to place this method at the disposal of even those of moderate means.

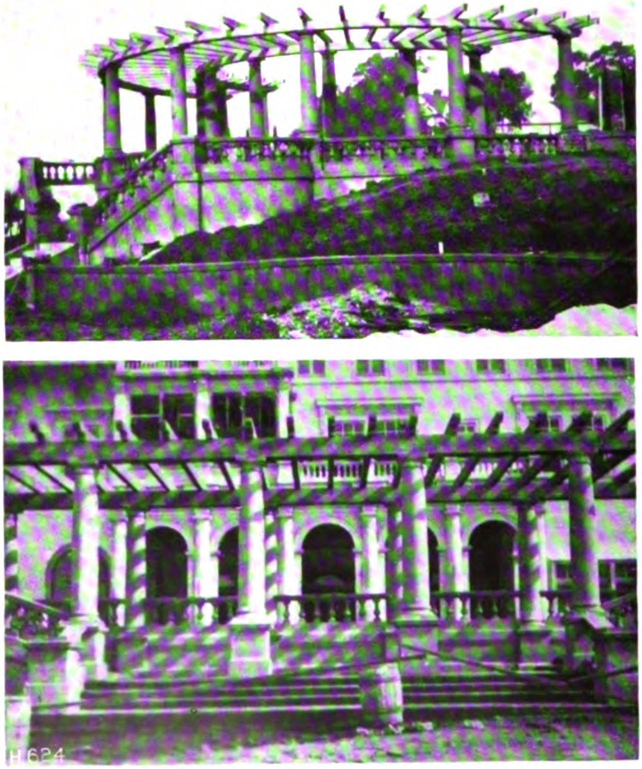
Great improvements have taken place in the method of making artificial stone. Colours are now various but uniform; the facing material is carefully selected, the sand used for the latter is clean, machine-dried, screened and crushed, and the mixture passed through millstones to give absolute uniformity of colour and a surface and texture equal to the best natural stone. Any sandstone or granite can be accurately imitated in texture and colour.

The photographs

EXAMPLES OF CONCRETE ORNAMENTAL WORK IN CALIFORNIA.

reproduced herewith illustrate some of the uses to which moulded concrete is being put to-day in the embellishment of gardens. They are of the house and grounds of a well-known capitalist of California, designed by Messrs. Hudson & Munsell, of Los Angeles. The house is an imposing structure two and a half stories high, covering a ground space of 120 ft. by 70 ft. It contains eighteen rooms, as well as several bathrooms and semi-enclosed sleeping rooms or porches.

The exterior is cement plastered on metal lath, set off by a green-coloured roof of Mission clay tile. The trim window balconies, elaborate entrances, balustrades, pergolas, ornamental railings, winding stairways, urns, and other embellishments of house and garden are of artificial stone cast by the California Ornamental Stone Company.



Examples of Concrete Ornamental Work in California.

REINFORCED CONCRETE IN CALIFORNIAN WINE PLANT.

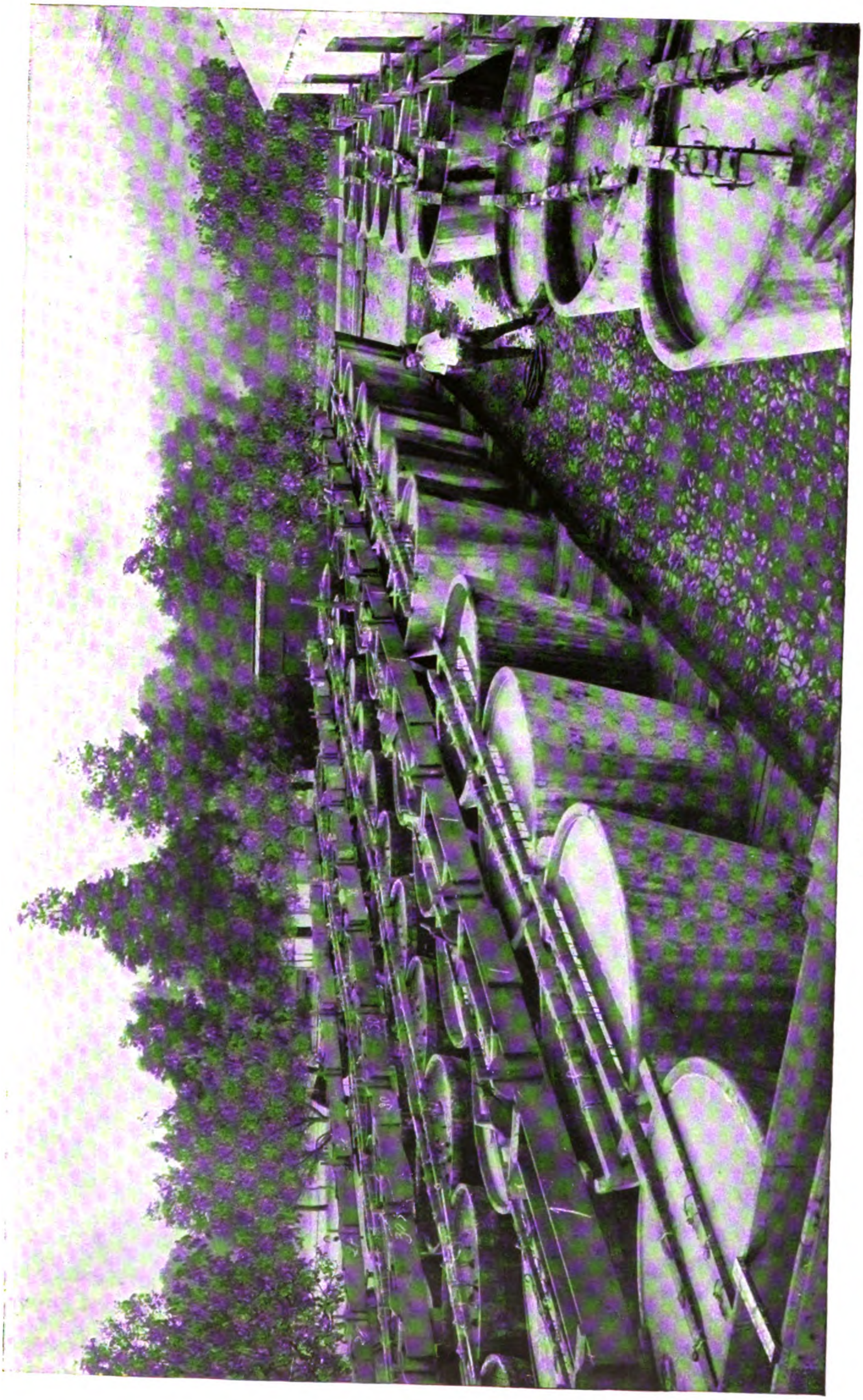
One of the new uses to which reinforced concrete is to-day being put is interestingly demonstrated by a visit to the institution in the vineyards of the Italian-Swiss Colony at Asti, Sonoma County, California, planned by Monsieur Charles Jadeau, the French champagne expert.

A recent visitor to the colony was especially impressed by the tremendous amount of concrete that has been introduced into the handsome buildings, and the novel and important uses to which this valuable material can be put in the construction of a modern wine plant.

The first building to attract attention is the new reinforced concrete structure devoted to the sparkling wine department. It was completed last spring in time for the bottling, which began on May 1st, and is an imposing structure, 50 ft. by 100 ft., of two stories high. The upper floor consists of one large, airy room, which is devoted to bottling; while the ground floor is divided into two cellars, 25 ft. by 100 ft. A second wing, of the same capacity, is shortly to be started.

One of the chief advantages of a concrete building for a champagne cellar is the ease with which the temperature of the vaults may be controlled in the hot summer and in the cold winter months in Sonoma. This is an important factor, as atmospheric conditions play a very large part in the process of fermenting wines in the bottle.

Opposite the champagne department is the distillery, the framework and foundations of which are of reinforced concrete. At the foot of this building is a row of forty



Reinforced concrete cream of tartar vats.

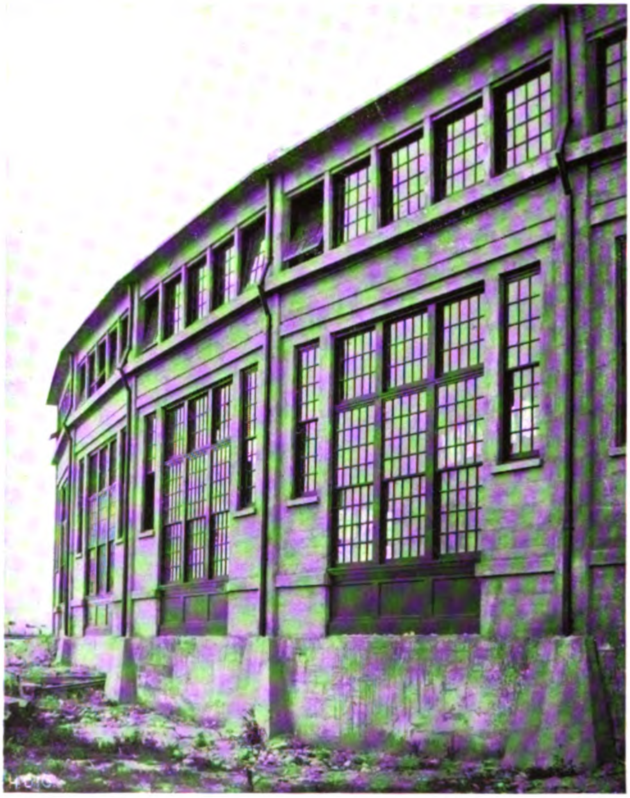
REINFORCED CONCRETE IN CALIFORNIAN WINE PLANT.

concrete flower pots, each measuring 4½ ft. high, 19 ft. circumference of top, and 13 ft. at the bottom, which are shown on p. 777. These are used in the manufacture of cream of tartar. After the alcohol has been extracted in the distillery, the hot sediment of the new wine is pumped into large vats. When the liquid is cool the hem covered with crystals is removed and spread out to dry on the concrete cover of the largest wine cistern in the world.

This cistern, 84 ft. long by 34 ft. wide by 25 ft. high, is carved out of the solid rock, and is lined with a 2 ft. thickness of Portland cement with a glazed surface. The upper sides and the roof are of reinforced concrete.

All the buildings have massive concrete foundations. There are several concrete fermenting tanks, having a capacity of 30,000 gallons, all of which are reinforced by steel rods. On a hill near by is a large concrete reservoir.

We are indebted to *The Cement Age* for the above information and for the illustration on p. 777.



Round house, showing construction for lighting.
Concrete Round-houses on the Santa Fé Railway

CONCRETE ROUND-HOUSES ON THE SANTA FÉ RAILWAY, U.S.A.

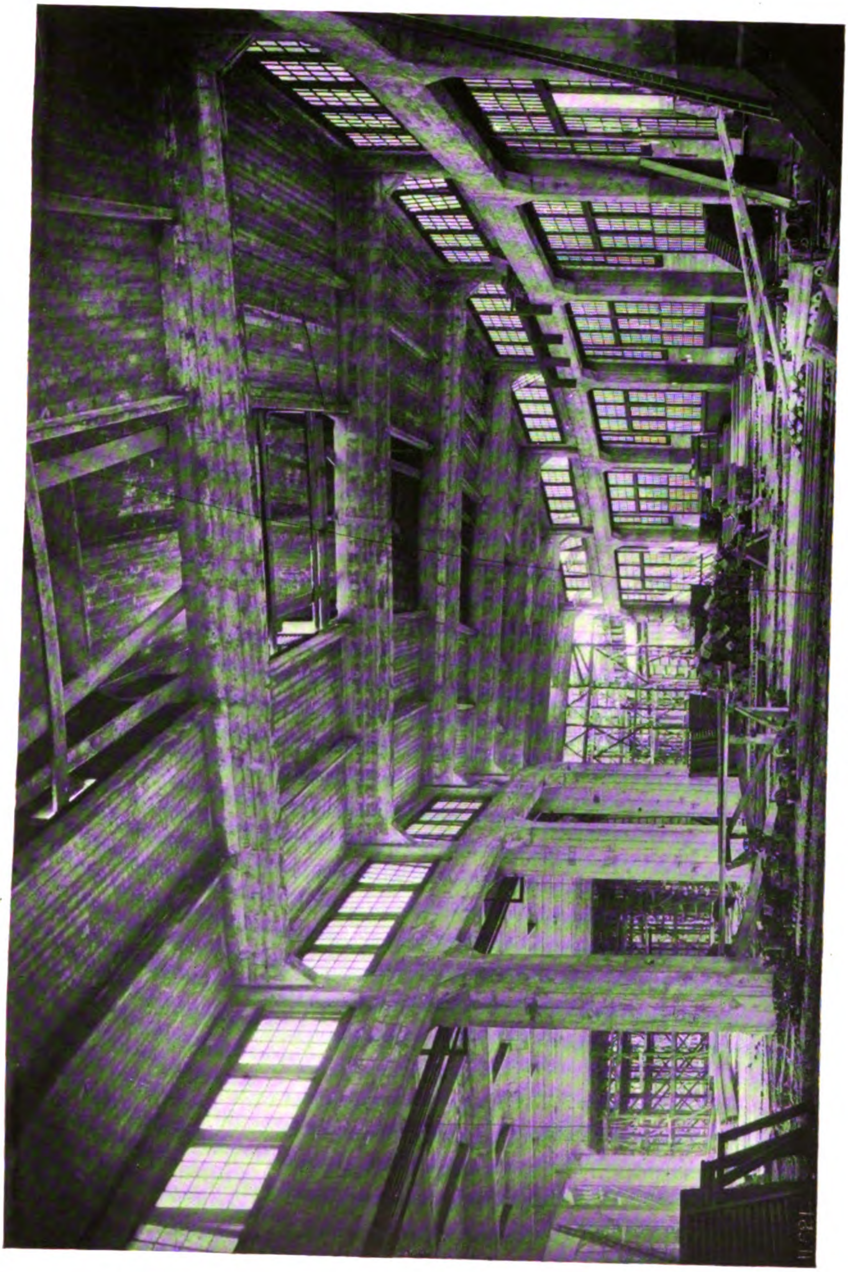
The railway companies in the United States have found by experience the many advantages of using reinforced concrete where permanent structures are required. This is particularly evidenced by the fact that the Santa Fé Railway Company has recently invested approximately $1,000,000 (£400,000) in this class of construction. Among others, a freight depôt, passenger depôt, hotel and power-house have been erected, and round-houses at four different places on the line. All were constructed from the plans of Mr. Harrison Albright, supervising architect.

The round-houses, shown in the accompanying illustrations, are supposed to be the largest of this type of structure in America.

They are 850 ft. by 94 ft. with thirty-five stalls; each stall is 92 ft. long, divided into two sections. The width on the inner circle is 14 ft., and on outer circle 25 ft. 6 in. The columns in the inner circle are 22 in. by 39 in., those at the centre of stall 18 in. by 40 in., and in the outer circle 22 in. by 39 in. The columns of the outer circle and in the centre of the stalls are of these dimensions for the purpose of carrying the travelling crane beam girders. The columns are reduced in section and carry roof girders.

The radial lines of girders are placed on a slope, the columns being 17 ft. 6 in. above rail on inner circle and 26 ft. above rail on inner circle and 26 ft. above rail on the outer circle.

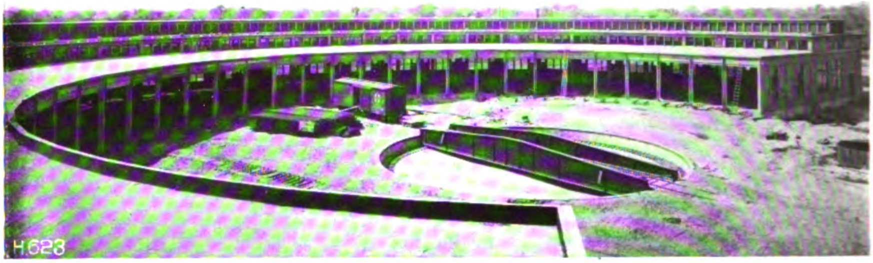
Ten longitudinal beams intersect the roof girders, and on top of the roof girders and beams is a roof slab 4 in. thick. The roof girders in the high part of the building, which carry clearstory longitudinal beams and roof, are 11 in. by 33 in. The crane beam girders carrying the travelling crane are 13 in. by 30 in. on both inner and outer



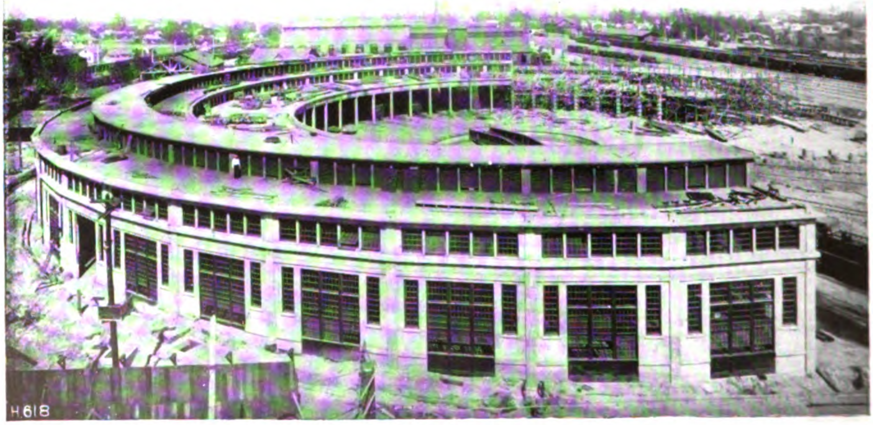
Interior View of Round-house, San Bernardino, Cal.
CONCRETE ROUND-HOUSES ON THE SANTA FÉ RAILWAY, U.S.A.

circles. The longitudinal beams are 5 in. by 13 in.; the clearstory girders are 5 in. by 18 in.

The exterior walls are 7 in. thick. The reinforcement in the footings, columns, beams, etc., is varied on account of different loadings. All footings, columns, girders, beams, walls, roofs, walls of ring pits, engine pits and drop wheel pits are of reinforced concrete. The doors on inner circle are of the rolling steel type; all doors and windows are wood, glazed with wire and glass.



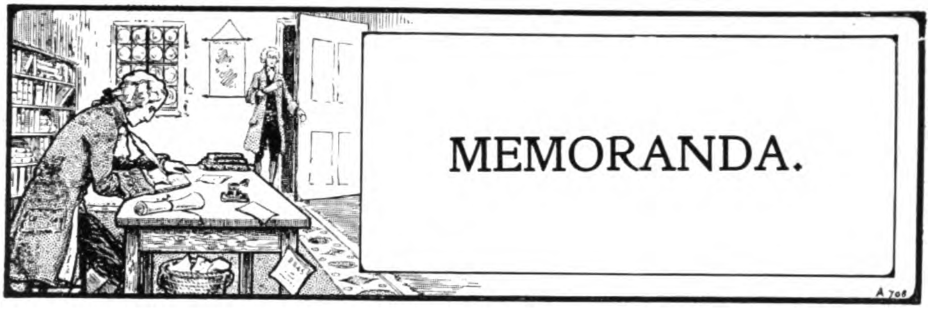
Exterior View of Round-house at Bakersfield, Cal.



Round-house at San Bernadino, Cal., in course of construction.

CONCRETE ROUND-HOUSE ON THE SANTA FÉ RAILWAY, U.S.A.

The Santa Fé Company has adopted this design as the standard for future round-houses, after careful consideration of initial cost, cost of maintenance and cost of insurance. The initial cost is found less than any other type of fireproof construction, and there are no maintenance charges. As it is believed that reinforced concrete will improve with age, the cost of insurance is less than any other type of construction; in fact, the liability of fire is so slight that no insurance will be carried on these buildings.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

THE PORTLAND CEMENT INDUSTRY.

Meeting of the Associated Portland Cement Manufacturers (1900) Ltd.—The annual meeting of this important Corporation took place on September 22nd, Mr. F. A. White presiding. The meeting marked the conclusion of the first ten years of the Company's work, which meant, among other things, a modernisation of its plant at a cost of just over £1,000,000, and expenditure on upkeep and repairs of plant to the amount of £1,200,000.

The Chairman's address, which covered, as usual, a wide range of technical questions, included the following observations *re* the Cement Standards Committee and Reinforced Concrete.

Portland Cement Standard.—" I have talked to you more than once of the British Standard specification for Portland cement. Quite recently the Engineering Standards Committee of experts have effected a second revision of this specification. It used to be urged in objection to the idea of a standard specification that it would tend to bring all brands to one level, and injure the prestige of the best-known cements. But the day has passed for these forebodings. A larger view has to be taken by manufacturers as well as consumers. Why should we complain of being kept up to the mark and stimulated to maintain our leading position? Again, we cannot supply the whole of the cement that is wanted; why not welcome the fact that others are kept up to the mark as well as ourselves, and that the English cement trade as a whole more and more ceases to fear comparison with the whole of the American or German or French cement trade? There is no doubt that the action of the committee has improved the British standard of quality, and we have the advantage of not requiring any longer to cope with the multiplicity of small differences which naturally existed when engineers, each with a different experience, and probably each with a weak point in his mind to guard against, made his own specification, to the infinite complexity of the manufacturers' task. Before there was a standard, many a contract was subject to no specification, and it would be interesting to know what it is that has often been supplied under the simple name of cement or Portland cement, which enabled a contractor or builder to use even the Belgian imported article, which to the trade is known as 'Natural cement.' Whether finality has been reached and whether the standard of to-day will be more or less stringent five years hence it is difficult to predict. There are points in which too great stringency is apt to favour theory at the expense of practice, but at present it does not look as though much change were likely, although the Institution of Civil Engineers, the Royal Institution of Naval Architects, and other technical bodies and their members will not fail to communicate to the committee new experiences, and these will be sure to be studied, and, where ground exists, allowed to influence its action. I may add on the subject of Belgian importation that the introduction of the standard has undoubtedly hindered the nefarious action of some persons in this country who did not hesitate to pass off the inferior foreign article as being of British manufacture. Small consumers, whose aggregate consumption of cement is large, have often been deluded, for most of them demand no specification—nor need they, if they buy the best British brands. But now they may, if the idea occurs to them, inquire if the brand they purchase complies with the standard, and in any case they should insist on a categorical statement that the cement they purchase is artificial, not natural, which would exclude the possibility of getting the Belgian natural article, unless the seller employs means absolutely fraudulent. I need hardly add that we should advise them to ask for one of the Associated brands! The natural decline of Belgian importation is significant, as you will see when I mention that that of the bygone year is only some 25 per cent. of the quantity received in this country in the year 1904.

Reinforced Concrete.—" Before I leave the question I may add that all that I have ventured to predict about the use of reinforced concrete is being realised. Its use is extending over the whole world. I was interested to see recently in Austria how much it is being employed by the railways for station roofs. At Nuremburg, for instance, where the station is quite as large as Charing Cross Station, the whole of the roof and its supports is constructed in this material, which offers the advantage of requiring absolutely no attention or repair. The Concrete Institute continues to collect and spread information on the subject, and amongst its proceedings in the past year has been the organisation of a visit to Paris, where the material has been in use longer than here, in order to investigate certain works done many years ago. I was myself one of the party, and we had ocular evidence that the steel embedded in concrete nearly two generations ago is, on being uncovered, found to be as bright and unrusted as when the work was done. We also visited work of recent date, and had not only a most interesting time from the technical point of view, but the cordial hospitality we received from engineers of the Ponts et Chaussées, as well as contractors who make a speciality of concrete work, established relations between our Institute and their corresponding bodies which we shall not fail to keep alive. At home, as well as abroad, the increase in the application of reinforced concrete to general building and engineering purposes is noteworthy. The War Office, the Admiralty and His Majesty's Office of Works continue to use it largely, for reasons both of efficiency and economy. Its use for municipal purposes, however, continues to be much hampered owing to the ultra-conservative attitude of the Local Government Board, who control the loan periods on municipal works. They almost invariably will only allow a much shorter period for works of reinforced concrete than for those of ordinary building materials, such as brick, timber or metal. This action is in marked contrast to that of the Local Government authorities in Ireland, who wisely determined to place reinforced concrete on equal terms with other building materials. Advantage has resulted from the powers that were obtained by the London County Council last year to amend the building regulations so that the use of reinforced concrete on the external walls of buildings in London might be sanctioned. Provincial centres have followed the Metropolitan example, and there is a general tendency amongst them either to apply to Parliament for similar powers to make regulations, or to amend their by-laws in the same sense. The Institution of Civil Engineers, which has been very deliberate in endorsing reinforced concrete as a material for important works, formed a committee last year to consider the matter, and this committee has just published an interim report, which does not make recommendations, but only states the position of affairs at the moment. I understand that the evidence of leading engineers is published in it, and a notable feature of the report is that this evidence is unanimous as to the economy of using reinforced concrete. It is to be hoped that the institution will in its coming session extend this report, and thus add to its weight. Rapid strides have been made during the year in the application of this material to numerous minor purposes in which it is a useful and economical substitute for timber and metal, such as railway sleepers, fence posts, telegraph posts and pipes. The hollow concrete block industry is also making good progress, and will almost certainly become a considerable outlet for Portland cement in future. This system replaces brickwork in a very satisfactory manner, and shows an economy in construction both as regards the materials and labour. It is more particularly applicable for cottages and small house property, but it is also being satisfactorily used for larger structures, such as engine houses, warehouses and water reservoirs. We know of one colliery district where several thousands of these cottages are at the present time being constructed and arranged for. The saving which will result, as compared with other building materials, represents a very large amount. Factories are also being erected for the manufacture of cement slates, an industry which in recent years has made great progress on the Continent."

GENERAL.

British Standard Specification for Portland Cement.—We have received from Mr. Leslie Robertson, M.Inst.C.E., Secretary of the Engineering Standards Committee, the revised edition of this specification. We comment on it in our editorial columns, but would here mention that the Sectional Committee on Cement is constituted as follows:

Sir William Matthews, K.C.M.G. (Chairman), representing the Crown Agents for the Colonies.

T. Sims, Esq., C.B., representing the Admiralty.
Lewis Solomon, Esq., representing the Royal Institute of British Architects.
Bertram Blount, Esq., representing the Institute of Chemistry.
Maurice Fitzmaurice, Esq., C.M.G., representing the London County Council.
H. W. Anderson, Esq., representing the Concrete Institute.
Sir John Mowlem Burt (John Mowlem Burt & Co., Ltd.).
H. K. G. Bamber, Esq., E. W. Brooks, Esq., and H. E. Brooks, Esq. (Associated Portland Cement Manufacturers (1900) Ltd.).
A. C. Davis, Esq. (Saxon Portland Cement Co., Ltd.).
Francis Fox, Esq. (Sir Douglas Fox and Partners)
H. Howard Humphreys, Esq. (Cement Users' Testing Association).
Anthony G. Lyster, Esq. (Mersey Dock Estate).
Charles S. Meik, Esq.
E. E. Pearson, Esq. (S. Pearson & Son, Ltd.).
W. H. Roberts, Esq. (W. Lee, Son & Co., Ltd.).
W. W. Squire, Esq. (Bristol Docks).
J. Warbrick, Esq. (Sir John Jackson, Ltd.).
C. H. Watson, Esq. (I. C. Johnson & Co., Ltd.).
M. F. G. Wilson, Esq. (Engineer-in-Chief, Midland Railway Co.).
G. N. Yourdi, Esq. (late Birmingham Water Works).

Leslie S. Robertson, Esq. (Secretary). Charles Dresser, Esq. (Assistant Secretary).

In the prefatory note to the specification, which is dated August, 1910, the Committee write as follows:

> "Since the issue of the first revision of the Specification the Committee has continued its investigation into the question of the determination of the initial setting time of cement. It was found that while the final setting times determined by the British Standard and Vicat Needles approximated very closely, the initial setting time as determined by the British Standard Needle differed considerably from that given by the Vicat Needle which is in general use, and also from that obtained by the rough-and-ready test of the finger nail.
>
> "It was considered preferable that one instrument only should be specified for determining the initial and final setting times of cement, and the Vicat Needle has been adopted for that purpose.
>
> "The Committee has also considered the question of inserting a clause in the Standard Specification to provide against the expansion of cement in cold water, but as the result of experimental investigation they recommended that no test of the plunging type be inserted, as it depends upon the setting time of the cement rather than upon its soundness.
>
> "In regard to chemical composition, a minimum lime content has been inserted with a view of excluding cements other than Portland cements, the total loss on ignition has been specified to provide an additional criterion of the quality of the cement and to restrict the amount of water present, and provision is now made for limiting the total amount of sulphur present in the cement, whether in the form of sulphides or of sulphates.
>
> "The instructions for gauging cement have been slightly modified with a view of removing as far as practicable any ambiguity as to the actual consistency of the cement which may have existed under the previous instructions, and the growth of tensile strength of cement and sand briquettes has been graded in a similar manner to that of neat cement briquettes.
>
> "The text of the Specification has been subjected to scrutiny by Mr. A. A. Hudson, barrister-at-law, with a view to ensuring that, as far as practicable, it has the meaning the Committee intended it should have, and the Specification has been remodelled in accordance with his advice.
>
> "The Specification in its present form was approved by the Sectional Committee on April 20th 1910, and by the Main Committee on June 10th, 1910."

The specification is obtainable at the offices of the Engineering Standards Committee, 28 Victoria Street, Westminster, S.W.

Papers on Concrete.— With the object of encouraging the contribution of useful papers on the materials employed in and the applications of concrete, in either the general or the special aspects of the subject, the Council of the Concrete Institute

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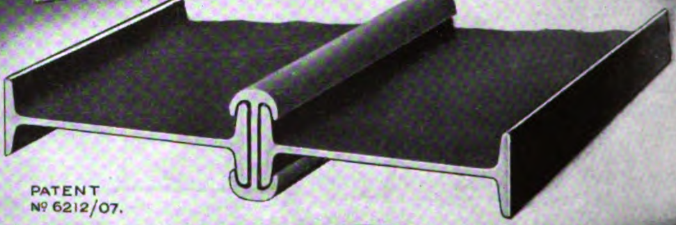

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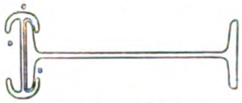

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15 in. × 5 in.	43 lbs.	39·5 lbs.	15·5 lbs.	·4 in.	·60 in.	·5 in.	·25 in.
12 in. × 5 in.	52·8 lbs.	39 lbs.	15·5 lbs.	·44 in.	·664 in.	·5 in.	·25 in.
10 in. × 5 in.	58·4 lbs.	35 lbs.	15·5 lbs.	·42 in.	·628 in.	·5 in.	·25 in.
8 in. × 5 in.	62·09 lbs.	28 lbs.	15·5 lbs.	·35 in.	·575 in.	·5 in.	·25 in.
6 in. × 5 in.	76·2 lbs.	25 lbs.	15·5 lbs.	·41 in.	·52 in.	·5 in.	·25 in.
5 in. × 5 in.	88·18 lbs.	24 lbs.	15·5 lbs.	·37 in.	·551 in.	·5 in.	·25 in.

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have decided to award a medal annually for the paper which they consider to be of the greatest merit in each session. Communications on the subject should be addressed to the Secretary of the Concrete Institute, 8 Waterloo Place, Pall Mall, S.W.

The Second Exhibition of the Clay, Cement and Lime Industries in Berlin (June 1st to July 18th, 1910).—From an account of this exhibition by E. Conrad in *Armierter Beton* we learn that it was held near the Baumschulenweg Station in the south-east of Berlin, and is considered to have been very successful. The number of exhibitors in the reinforced concrete section was small, but structures in this material were shown by Messrs. Wayss & Freitag, Messrs. Steffens & Nolle, The Kahn Bar Co., Aktiengesellschaft für Beton und Monierbau, and M. Czarnikoff, all of Berlin; Messrs. Wrissenberg, of Bremen; Messrs. Kell & Löser, of Dresden; Messrs. Weirich & Reinken, of Stettin; and Messrs. Rud. Wolle, of Leipzig. The latter firm also supplied the masts carrying the electric cables over the grounds.

In the machinery section an important place was occupied by mechanical excavators for extracting raw material and transporting machinery for conveying it to the factory. Many concrete mixing machines were also shown, the principal exhibitors being Messrs. P. Deutsch & Co., Berlin, Karl Peschki, Zweibrücken (Palatinate), The Sonthofen Co., Messrs. Gauke, Gockel & Co., Oberlahnstein, and others.

An elaborate exhibit illustrated the work of the Royal Material-Testing Station at Gross-Lichterfeld, and other testing laboratories, particularly that of the *Tonindustrie-Zeitung*, were also represented. Further, a number of technical schools illustrated their methods of giving instruction in the use of the various building materials. Weekly lectures were also given on matters connected with building construction and the use of the materials exhibited.

The exhibition was well attended, and several technical associations took occasion to hold their meetings in the buildings.

Yorkshire Building, Sanitary and Allied Trades Exhibition.—The Yorkshire Building, Sanitary and Allied Trades Exhibition will be held at the Artillery Drill Hall, Edmund Road, Sheffield, from October 14th to 22nd, 1910.

It has been decided to promote this exhibition at the request of a number of prominent firms in the building and allied trades, as it was felt that great benefit should result to the trade generally in Sheffield and district by an exhibition of this character, carried out under the direct patronage and support of the local associations interested.

Machinery and Engineering Exhibition, Manchester.— The Engineering Exhibition at City Hall, Manchester, organised by the Proprietors of *The Engineering Review*, seems likely to be a great success. Many novelties in design, and improvements in existing designs, will be shown for the first time. No engineering exhibition has been held in Manchester for twenty-two years, which fact should ensure a large attendance. The opening ceremony will take place on October 14th, and will be presided over by the Rt. Hon. Sir George Reid, P.C., K.C.M.G., High Commissioner for Australia.

Early Use of Reinforced Concrete.—It has been stated that evidences have been discovered of the reinforcement of concrete in the roof of a Roman tomb, constructed some hundred years B.C., wherein bronze rods were found crossed latticewise.

The following letter addressed to Mr. Charles F. Draper, A.M.Inst.C.E., by Professor Lauciani, the eminent Roman archæologist, affords pretty clear evidence of such construction having been adopted in the roof over the *frigidarium* in the Baths of Caracalla on the Via Appia, Rome, which appear to have been constructed in the year 212 A.D.

The *frigidarium*, or the chamber containing the cold bath, was of large extent, and the reinforcement of the roof slabs, no doubt, facilitated the construction of a larger unsupported area than would otherwise have been possible.

HOTEL BELLEVUE, BAVENO, LAGO MAGGIORE,
September 22nd, 1907.

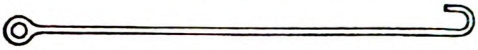
Your letter of September 9th has reached me here, after many wanderings through Switzerland and Tyrol. The discoveries mentioned by you took place in 1872 or 1873, therefore I must refrain from mentioning particulars which are not clear and certain in my recollection.

I remember beyond any shade of doubt:

(1) That the concrete, of which the ceiling of the *frigidarium* was made (many fragments

of which were lying on the floor) was composed of a mixture of cement (pozzolana $\frac{2}{3}$, lime $\frac{1}{3}$) and of pumice stone, so light that a workman could easily lift by the hands blocks of great size;

(2) That mixed up with the *débris* were bars of rusty iron of the following shape;



ABOUT 3 FT.

(3) That the number of the bars found was about 100;

(4) That the bars bore marks of having been embedded in masonry;

(5) That all the rubbish was (most unfortunately) sold by the commissioner for the excavations, Pietro Rosa, to the contractor for the works, who made use of it in building large stables for his horses outside the Porta S. Giovanni on the left. These stables are still in existence.

R. LAUCIANI.

We are much indebted to Mr. Draper for sending us this interesting communication.

CATALOGUES.

Richard Johnson, Clapham & Morris, Ltd., have sent us a well-illustrated pamphlet descriptive of their steel wire lattice system of reinforced concrete. The special advantages of this system of reinforcement appears to be the fact that it can be made in long lengths up to 300 ft., if necessary, which ensures a continuous reinforcement from one end of the building to the other. The reinforcement is supplied in rolls, which makes it very convenient for use, and the cost of laying is also small, being about $\frac{1}{8}$d. per yard super.

A number of illustrations are given of different buildings, in England, Australia and Africa, in which Johnson's lattice reinforcement has been used.

The pamphlet also contains a table showing at a glance the thickness of concrete and the correct weight of lattice necessary to carry various uniformly distributed working loads, which are calculated at one-fourth of the ultimate resistance.

Altogether the pamphlet is well got up, and contains useful instructions as to the aggregate and cement to be used, as well as detailed directions for laying the lattice reinforcement.

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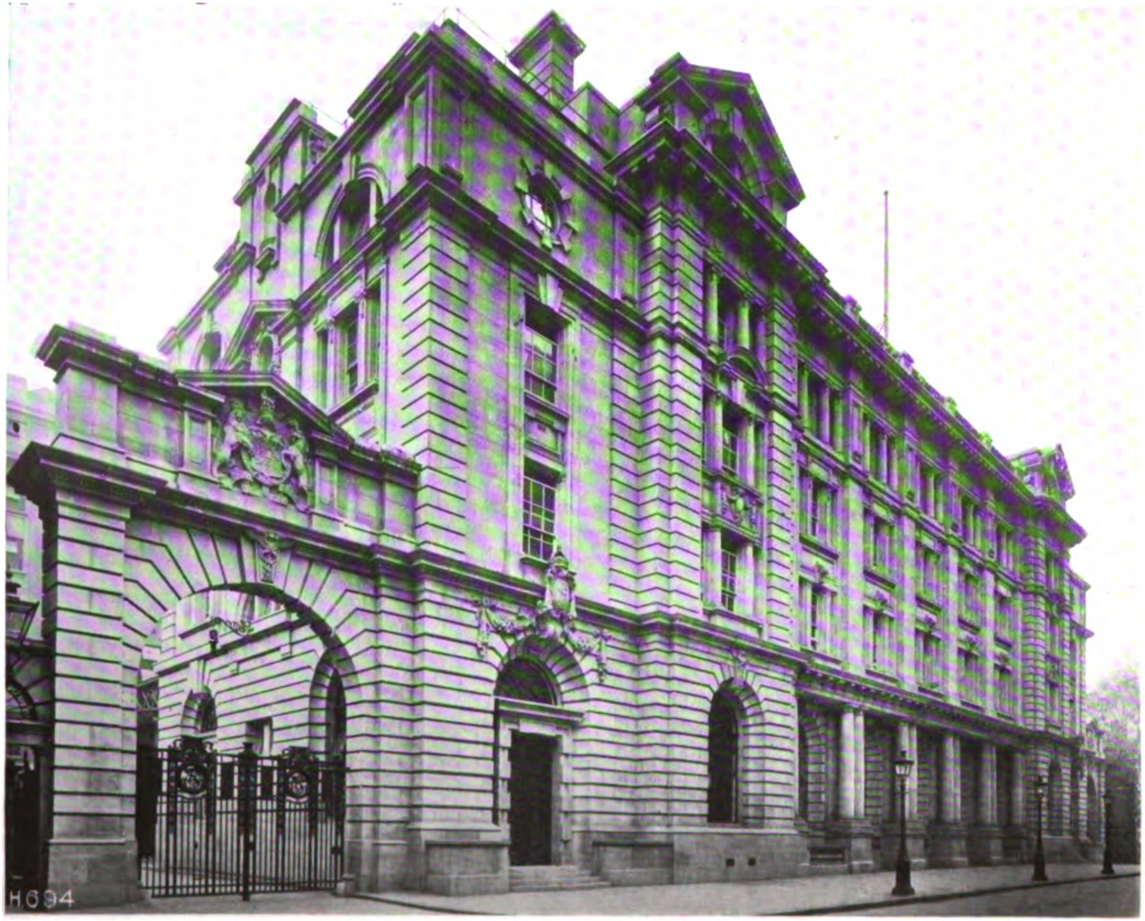


THE NEW GENERAL POST OFFICE BUILDINGS.
(Front to King Edward Street.)

(Frontispiece,
Opp. Contents.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume V. No. 11. LONDON, NOVEMBER, 1910.

EDITORIAL NOTES.

MODERN TOWN PLANNING AND CONCRETE.

THE movement towards modern forms of town planning, which has been so prominently before the public during the past month, claims the closest attention of all concerned in building and civil engineering works. Summarised, the results of this movement mean that during the next two decades there will be a vast amount of structural and civil engineering work connected with the laying-out of new urban, suburban, and rural areas, and that there will also be a great deal of work done under the head of " improvement schemes," leading to the demolition and reconstruction of the older parts of densely populated centres.

Modern systems of town planning have been practised on the Continent and in the United States for some twenty or thirty years, and among their greatest and most successful advocates have been the late City Engineer of Cologne, Dr. Stübben, and Mr. Burnham, the American architect, whose offices are at Chicago. The modern school of town planning as systematically developed, economically conceived, and most successful in results has, no doubt, been that practised in many German cities by the first-named advocate, Dr. Stübben, whose fame is world-wide, and the work he has planned may be found executed not only in Germany but in several other countries. Mr. Burnham's schemes, on the other hand, magnificent in themselves, are unfortunately, however, for the most part only so far on paper.

We, in this country, have only recently taken up the question, and then, until a year or two back, in a somewhat dilettante manner. But now, thanks in the first place to the energy of the President of the Local Government Board—with whose views on several other technical questions we regret we frequently have to differ—the Town Planning Act of 1909 has come into being, and municipalities throughout the kingdom are investigating what steps should be taken to help matters. The enthusiasm of the Right Hon. John Burns has been infectious. He can count numerous disciples among technical officials in Government employ, in municipal offices, and in private practice, and the enthusiasm has already resulted in what has been probably one of the most useful Conferences of recent times—viz., the Town Planning Conference so ably organised by the Royal Institute of British Architects, and supported by the Royal Academy of Arts.

Seeing that the modern lay-out of urban and rural areas will necessitate a vast amount of civil engineering and constructional work, we would here take the opportunity of pointing out the great advantage of a proper use of concrete, both plain, reinforced, and in the form of hollow blocks. To the civil engineering works in particular reinforced concrete should mean the saving of large sums of money. For road surfaces, pavements, and the like, Portland cement concrete and artificial stone should find much use, and not less important we think will be the application to buildings of the concrete block—more particularly the hollow concrete block that is favoured in the United States. There can be no doubt that the hollow block lends itself admirably to minor domestic work, being rapidly put into position, hygienic to a high degree, and suitable for artistic treatment. We believe that many of the town planning schemes of the next decade will have financial problems to face of no small account, and it is for that reason that we would so emphatically point to the advantages of concrete where economy will be an important factor.

THE TOWN PLANNING CONFERENCE.

AT the Conference in question, problems of architectural design or of structural material were rightly omitted. The field was a sufficiently vast one when limited to planning proper, but we would urge upon those who have the subject at heart that the time has come to call a second conference next year for the planning and structural features of domestic buildings, which should be considered in connection with modern housing and town planning schemes. The planning of minor domestic buildings is still a subject much neglected, and, apart from planning, we consider there has been neglect in considering the use of suitable materials for the construction and equipment of such smaller dwellings. We trust this side of the problem will also soon receive the attention it merits, and that influence will be brought to bear in those legislative quarters where the modernisation of "model" by-laws and the like might also tend towards improvements in plan construction.

The Conference was well organised, especially in matters of detail, and did very great credit to the Secretary-General, Mr. John W. Simpson, F.R.I.B.A., and his staff. Without good organisation such Conferences are only too apt to do harm, by disgusting those who participate in them, but in the organisation that was under Mr. Simpson's control, everything relating to the Conference must leave a pleasant memory in the minds of all those who took part in it. The printed matter in particular was exceptionally well thought out. That everything should have been printed in English and French does the organisers great credit, especially having regard to the fact that no very great attendance from abroad was expected. The handbook of the Conference, edited by Mr. Rudolf Dircks, was particularly useful. As to the exhibition at the Royal Academy, it was probably one of the most perfect of its kind that could have been devised, and there was little missing to prevent its serving as a complete pictorial history of the subject. The historical exhibitions at the Guildhall were also most successful, whilst one arranged in the library of the Royal Institute of British Architects, and dealing with the literature of the subject, also claimed close attention.

Enthusiasm on town planning must necessarily have a very favourable effect upon all problems of building, and if the Royal Institute of British Architects and the Royal Academy of Arts will continue to assist practical conferences and exhibitions of this description, they will be benefiting the community in a most effective manner, and last, but not least, they will assist in popularising the work which forms the basis of the prosperity of the members of the architectural and artistic professions.

THE CONCRETE INSTITUTE.

THE CONCRETE INSTITUTE has just entered upon its third session, and we trust it will be one of considerable activity and practical work. Its first year was devoted mainly to obtaining its incorporation and to most useful work on the scientific side—viz., the question of algebraical notation, etc., and the second year has been largely applied to perfecting its administrative arrangements. The time has now arrived when the serious and long-required technical and practical assistance to be expected of an institution of this kind should be rendered to those who are entrusted either with the design or with the execution of works in concrete and reinforced concrete.

On the administrative side there is little to complain of; the organisation, the rules and the standing orders obtained in the first instance for the Institute on incorporation have lately been improved upon. The services of a permanent Secretary of high technical attainments have now been secured, and the coming generation has also now been provided for by the formation of a students' section.

A PROGRAMME OF WORK.

What we, however, believe the membership expects of the Institute is, that it should assist in obtaining reasonable regulations for reinforced concrete both in the Metropolis and in Provincial centres; that it should assist in obtaining modifications in the antiquated "model" by-laws issued by the Local Government Board, and some radical change in the ultra-conservative practice of that department's policy regarding loan periods on reinforced concrete works. The members, we believe, expect the Institute to energetically co-operate in obtaining official and professional recognition for the standard recommendations as to reinforced concrete, originally devised by the Royal Institute of British Architects, and now in course of revision. Further, we think they desire the Institute to lay down standards as to practice, supervision, quantities, questions of arbitration, the relation of sub-contractors, and other practical matters of this kind, affecting reinforced concrete.

Next, as regards both concrete and reinforced concrete, we believe the membership anticipate that the Institute should use its influence in obtaining standardisation, not only of the algebraical notation, but also of the general language in which engineers and contractors describe their works—*i.e.*, for their drawings and their specifications.

Then comes the question of research work. We do not think the Institute is as yet financially strong enough to undertake research work of any great moment; nevertheless, it should use its influence to prevent the duplication of unnecessary experiments, and should guide those who desire to conduct investigations towards those paths which have not yet been trodden by the research men of this or other countries. The Institute should certainly see that the Physical Research Laboratory, or any other similar institution that carries out research work at the public expense, should only undertake such investigations as are really required by those who have to design or execute works. Tests or inquiries of a purely theoretical and academic value are not wanted until a number of more urgent practical matters have been dealt with. We also hold that the Institute should investigate failures in this country in the same manner as kindred institutions abroad have done as to accidents when they have occurred in their own localities. Reinforced concrete should not have the slur of failures that have little to do with the qualities of the material, *per se.*

Turning to mass concrete, there is so much still required in the way of information regarding this, that it would be difficult to specify what the Concrete Institute should do, but we think that there is no more urgent matter, as far as the community at large is concerned, than a careful inquiry into the experiments on the effect of sea-water upon modern Portland cement concrete, which, taken generally, has been so satisfactory, but which has, in one or two cases—either owing to bad workmanship or to poor material—given occasion for complaint.

The sphere of work for the Concrete Institute is, indeed, a vast one, and there is no doubt that not only the membership but also the public will expect it to do as much for concrete as the Iron and Steel Institute has done for steel.

ITS NON-METROPOLITAN MEMBERSHIP.

We believe it a matter of no small importance for the development of concrete in Great Britain and in the Empire generally that the requirements of the provincial men, and of those stationed in our colonial outposts, should not be overlooked, and we think it should be stated quite plainly that their requirements go beyond a mere reception of transactions containing the reports of papers read with an occasional note as to current inquiries. We, therefore, think that provincial and colonial branches should be formed at the earliest moment, and that these local organisations should be encouraged in every possible way by the London headquarters.

If the Institute in its next few years does sound scientific and practical work on the broadest lines, both in the Metropolis, in the great provincial centres and in our overseas territories, its success is fully assured.

BELGIAN "NATURAL" CEMENT — CUSTOMS AUTHORITIES' ACTION.

We understand that during the past few days a consignment of Belgian "natural" cement arrived at the Port of London, packed in sacks, bearing the name and trade mark of a firm of English makers, and with, of course, no words indicating the real nature or origin of the material. This is not only a serious violation of the Merchandise Marks Act, but the use of the name of an English maker is obviously a mean and despicable fraud of the worst type. Fortunately the Customs authorities were on the alert, and seized the shipment, but whether they will merely insist upon the proper qualifying words "made in Belgium" being branded upon the sacks, or whether they will confiscate the shipment and institute a prosecution, remains to be seen. Needless to say, we hope very sincerely that the latter course will be adopted. But for the prompt action of the authorities it is clear that this consignment of Belgian "natural" cement would have been sold in our markets as genuine artificial Portland cement manufactured by a British firm.

REINFORCED CONCRETE GRAIN SILOS AT SILVERTOWN.

Grain silos and impact silos of all descriptions lend themselves admirably to reinforced concrete construction, and we welcome the increasing use of this material for this class of structure, of which the Silvertown example here presented is a most instructive instance. —ED.

THE granary building erected at Silvertown for the Co-operative Wholesale Society, and described in this article, consists of eight cylindrical silos, each 80 ft. high by 20 ft. in diameter, rising from a substructure founded on Hennebique piles. The building also contains a number of tunnels or subways for the convenient transport of grain removed from the storage cylinders above. These cylinders are connected at the top by a roof building of one storey, which is in communication with the adjoining wheat receiving and silo building of the flour mill.

The total length of the building is 85 ft. 6 in. by 43 ft. 6 in. wide by 102 ft. high above ground level, or 110 ft. high, measured from the underside of the tunnels. Each silo has the storage capacity of 505 tons, or 2,242 quarters of grain, approximately, the total capacity being about 18,000 quarters.

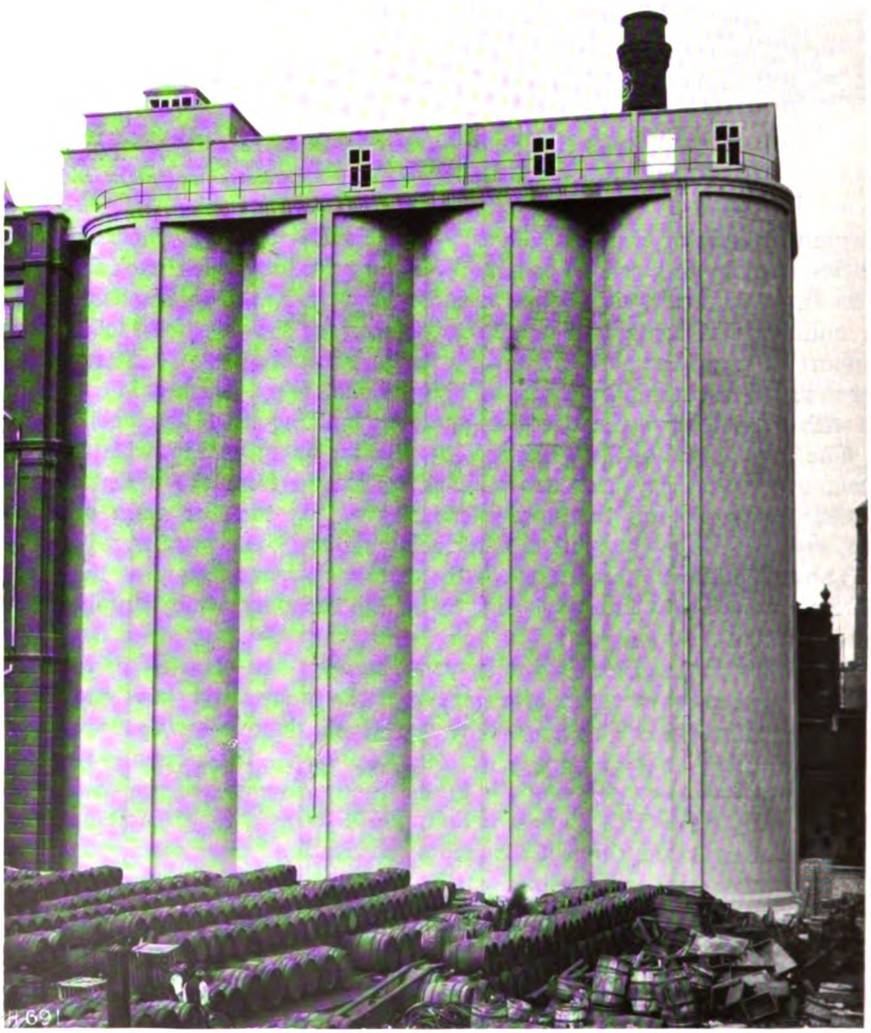
The economy of ground space is therefore very marked, and as the walls of the giant storage bins are only 6 in. thick, the economy of structural materials must be obvious.

In *Fig.* 1 longitudinal and transverse sections are shown. *Figs.* 2 and 3 are sectional plans showing the arrangement of the tunnels and silos respectively.

The foundations are supported by 124 Hennebique piles, 14 in. square in cross-section, and varying from 27 ft. to 35 ft. long. The piles are disposed in eight longitudinal rows, carrying the tunnels and columns, and are continued up from the piles to the arched construction, which forms a general foundation slab for the entire structure, three of the arches constituting tunnel roofs and the other two being filled with well-rammed earth. This method of foundation work has proved successful for the support of unusually heavy loads upon soil possessing little or no bearing capacity.

The three tunnels, one 8 ft. wide, the other two 5 ft. 6 in. wide, and all three 7 ft. high, extend for the whole length of the substructure, and are joined by a cross-tunnel, affording means of intercommunication. Below the floor of the cross-tunnel is an elevator chamber. The walls of all the tunnels are 6 in. thick and the floors 6 in. thick, the concrete of the walls being reinforced by a double network of thin steel rods, while the floors are reinforced as customary in the case of Hennebique beams and slabs subject to flexure. The columns serve the double purpose of stiffening the tunnel walls and of supporting the general foundation slab.

In order to secure the monolithic connection of the piles with the columns, beams, slabs, and walls at the floor level of the tunnels, the pile-heads were trimmed off level, leaving the longitudinal bars projecting for a short distance. To these bars the longitudinal reinforcement of the columns was attached, and the reinforcement of the connecting beams was suitably disposed. Then the concreting of the various members was conducted so as to make the whole perfectly monolithic and free from joints. A similar method of procedure having been followed in moulding all parts of the work up to the general foundation slab, the entire substructure became a cellular foundation, from which the piles project as



Reinforced Concrete Grain Silos at Silvertown.

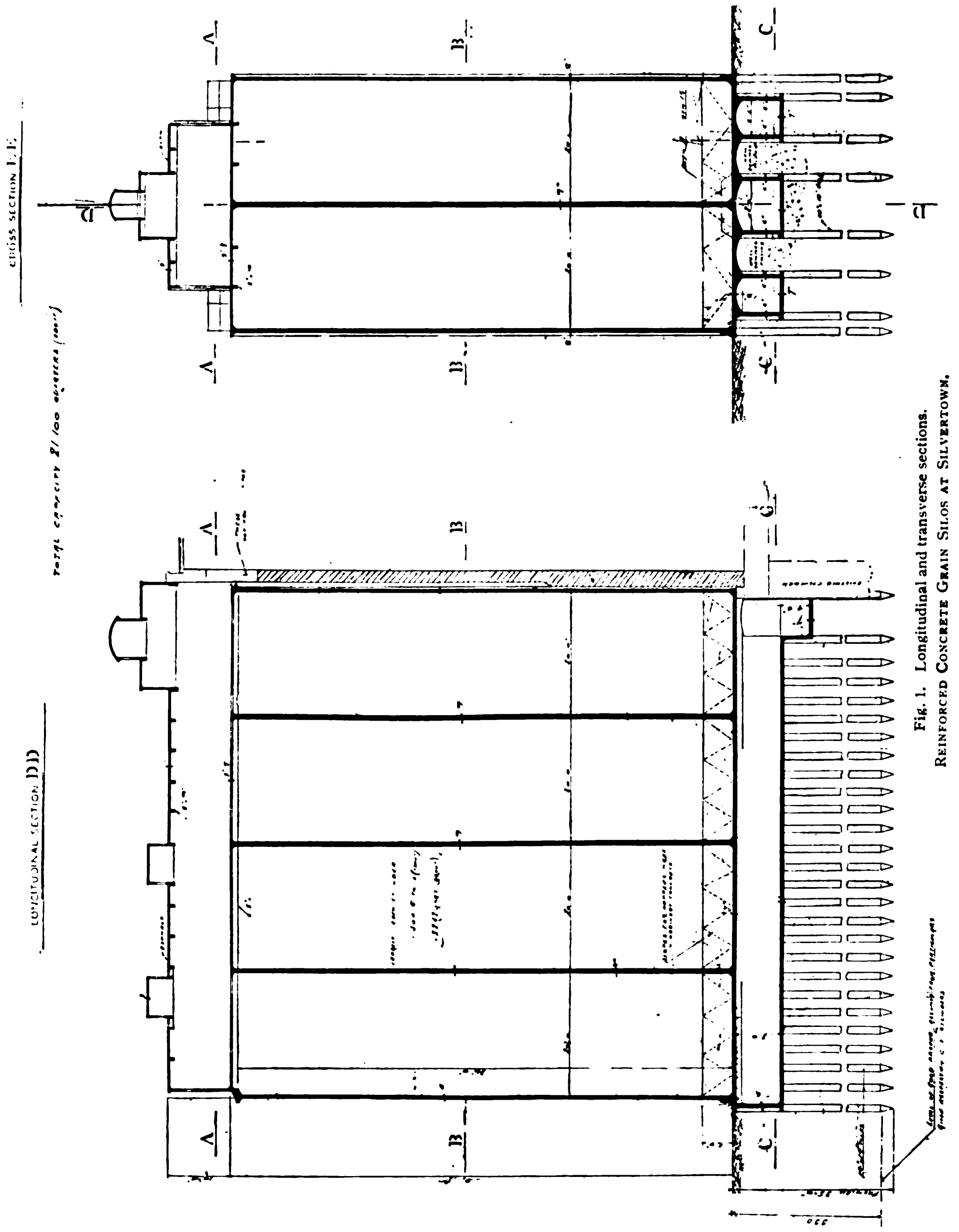


Fig. 1. Longitudinal and transverse sections.
Reinforced Concrete Grain Silos at Silvertown.

monolithic prongs deeply rooted in the earth. In virtue of this arrangement of design, the enormous load of the superstructure is most uniformly distributed.

Fig. 4 is a sectional plan showing arrangement of the roof.

In *Fig.* 5 we have an enlarged sectional plan giving details of the silo walls and the connecting reinforced concrete construction, into which the walls are merged for a distance of 8 ft. at three points around all the inner silos, and at two points in the case of the two end pairs.

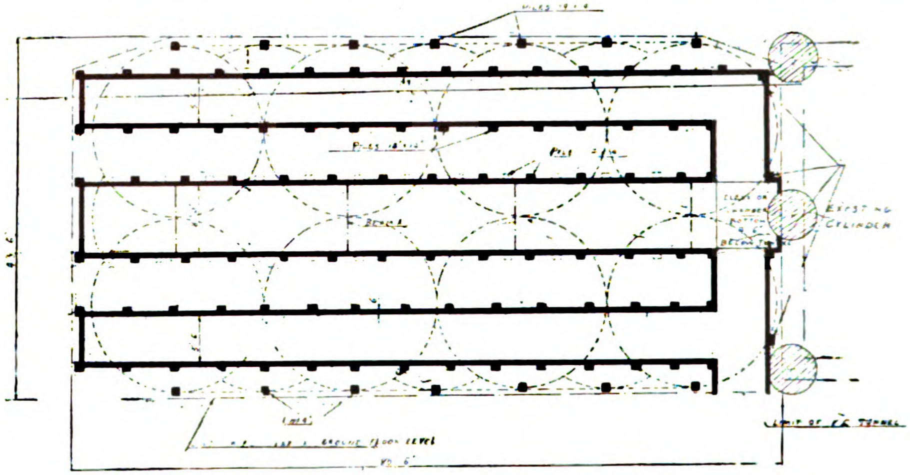


Fig. 2. Sectional plan showing arrangement of tunnels.

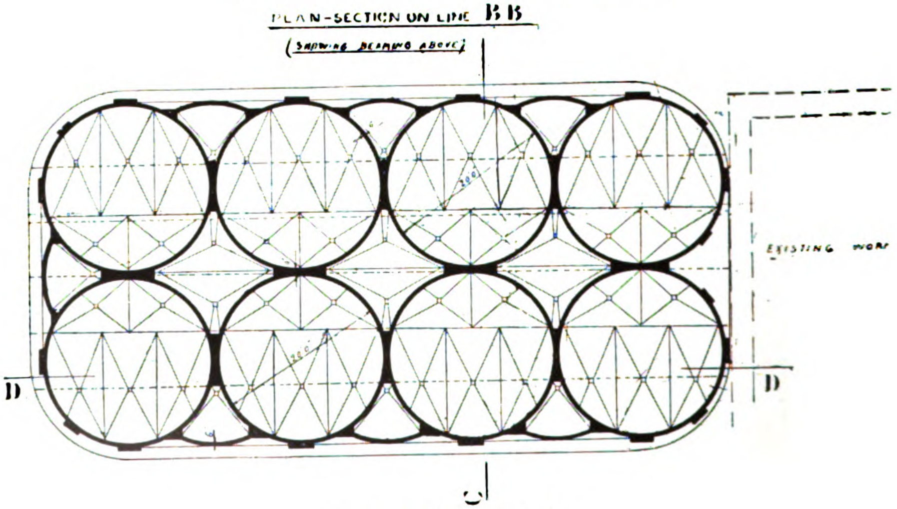


Fig. 3. Sectional plan of silos.

Fig. 6 is a horizontal section through the series of eight silos looking upwards, so as to include the beams supporting the continuous slab which forms the cover of the compartments and the flooring of the roof building.

It will be noticed that, in addition to being built monolithic, with the general foundation slab at the base, and with the covering slab at the summit, the silos are placed in monolithic connection at three or more points in their periphery, and

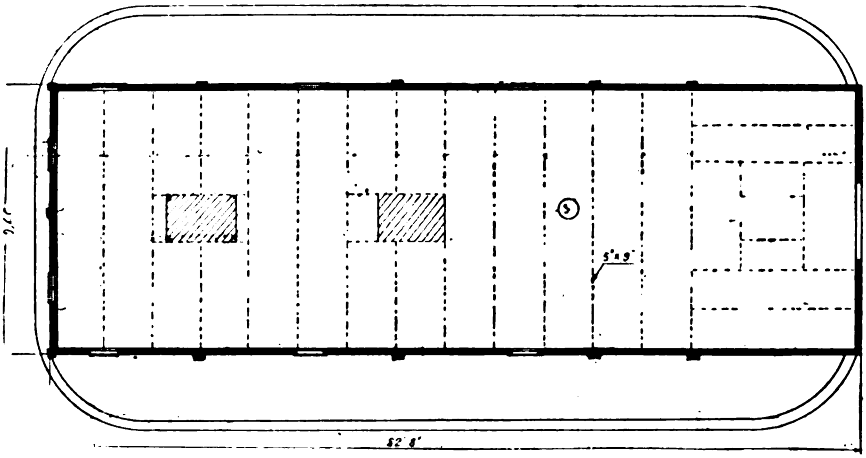


Fig. 4. Sectional plan of roof.

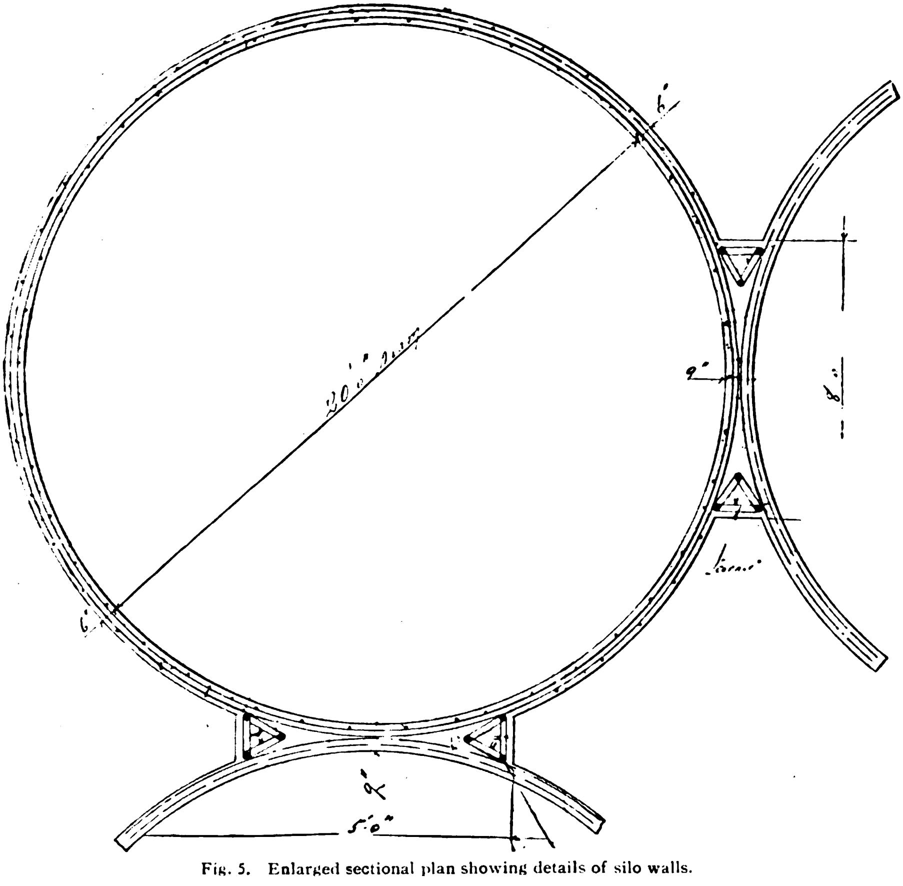


Fig. 5. Enlarged sectional plan showing details of silo walls.

that the outer silos are stiffened by vertical ribs or counterforts. The framework thus constituted has the effect of reducing the unsupported span of the cylindrical walls, which, although only 6 in. thick, are amply capable of resisting the heavy bursting strains due to the weight of grain stored.

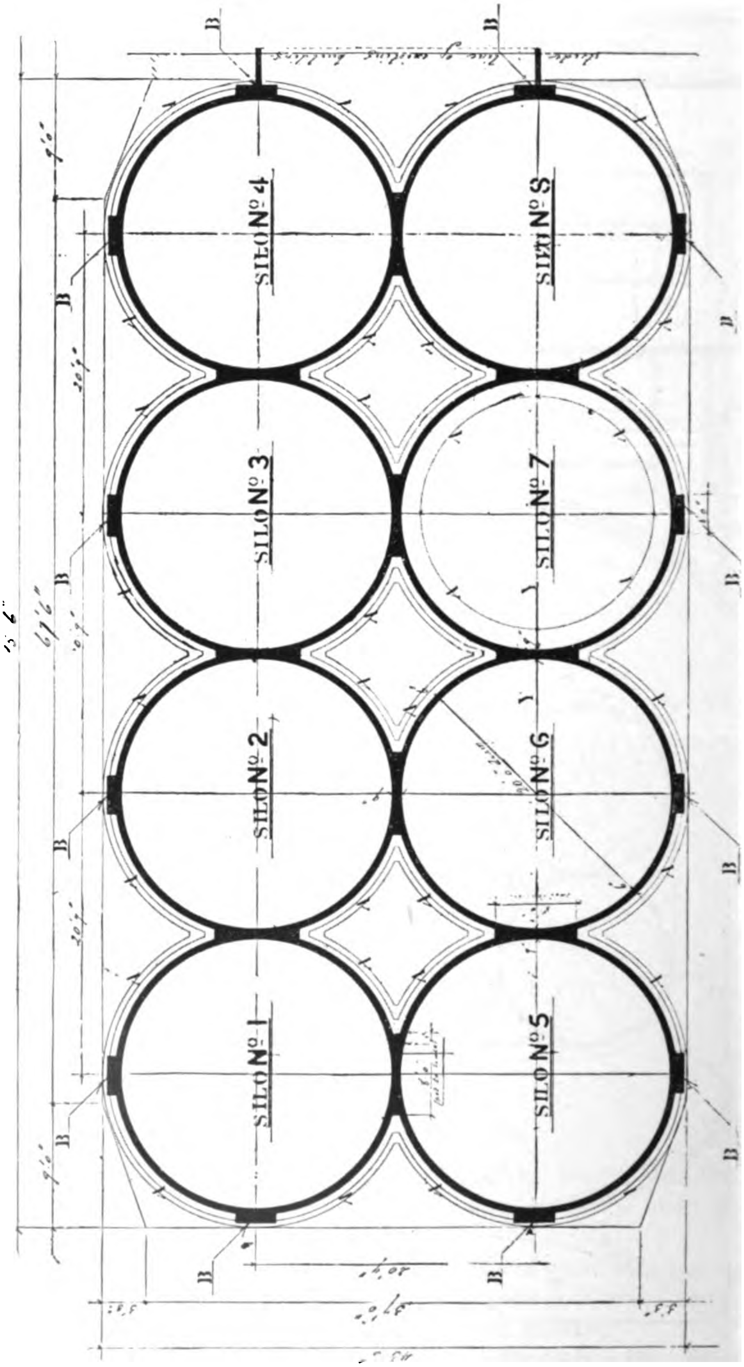
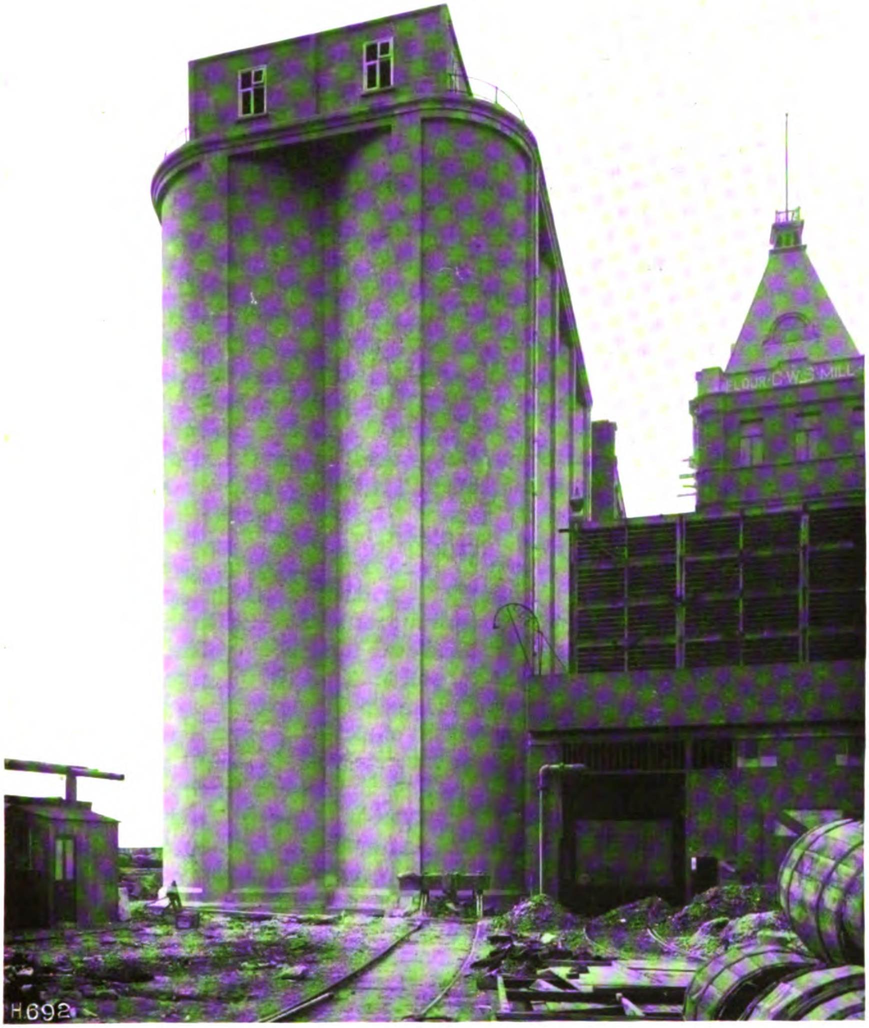
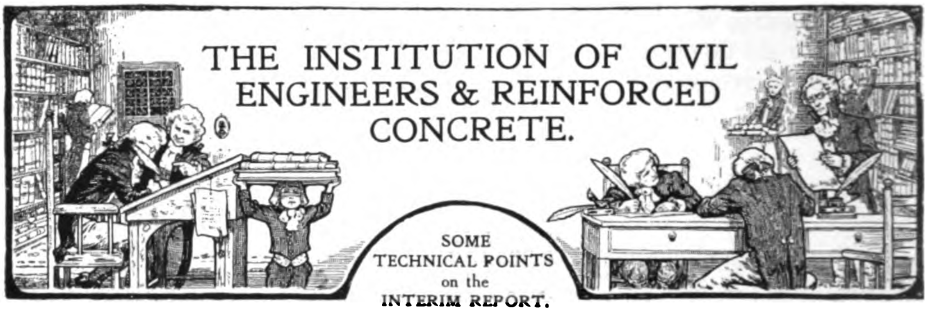


Fig. 6. Horizontal section through silos, looking upwards.
Reinforced Concrete Grain Silos at Silvertown.

The building was designed by Mr. F. E. L. Harris, A.R.I.B.A., of Manchester, architect to the Co-operative Wholesale Society, Ltd., for whom all details of the reinforced concrete were prepared by Messrs. L. G. Mouchel & Partners, of Westminster. Messrs. A. Jackaman & Son, of Slough, were the contractors.



Side view of silos.
Reinforced Concrete Grain Silos at Silvertown.



THE INSTITUTION OF CIVIL ENGINEERS & REINFORCED CONCRETE.

SOME TECHNICAL POINTS on the INTERIM REPORT.

Our views on the Interim Report of the Institution of Civil Engineers' Committee on Reinforced Concrete were expressed in an editorial and a special article published in our preceding issue. We are now dealing with some of the technical data contained in the report, which require analysis and criticism.—ED.

In our issue for last month we reviewed generally the Preliminary and Interim Report of the Committee on Reinforced Concrete, appointed by the Institution of Civil Engineers. We now resume our consideration of that report, as we stated we should, by dealing with: (1) Memoranda " D " and " E," which refer to experimental data in regard to the properties of materials employed in beams and columns of reinforced concrete, prepared by Mr. Edward William Hollingworth, M.A., Assoc.M.Inst.C.E.; (2) Addenda to Memorandum " G," which treats of the evidence and information given by engineers and contractors of experience in reinforced concrete on special points of the inquiry; and (3) Memorandum " H," which consists of reports on works executed.

THE COLLECTION OF DATA.

Firstly, in regard to Mr. Hollingworth's collection of data. Generally, it may be remarked that the references show neither the date of the experiments, nor of the whole governing conditions. Thus, experiments of Sir Benjamin Baker and Prof. Hartig, made a good few years ago, are cited as to the modulus of elasticity of concrete, and the same results refer really to mortar and neat cement, so are practically valueless. Mr. Hollingworth states that some writers have pointed out that a variation of 50 per cent. in the value of the ratio of the moduli of elasticity of steel and concrete makes only a little difference in the stresses in concrete with the usual percentage of reinforcement, and he contends, and gives an example to prove, that that is not so as regards the steel in pieces subjected to compression. That only shows the unfortunate way in which those who miss the point of an argument, and have insufficient experience in reinforced concrete design to guide them, will go astray, for the remarks referred to had reference to the ultimate resistence of *beams* and the percentage of tensile reinforcement, and is quite true and easily demonstrable. Reference is made to Bauschinger's ideal size for compression test specimens as being height 2½ times the width, but the ratio he advocated was 1½. The matter is, however, complicated by other considerations, and the results from cubes made in the ordinary way approximate more closely to the strength in actual work.

Reference is boldly made to some cements giving higher strength of concrete than others, but the importance of fineness of grinding is ignored.

Considère's views as to the extension of concrete under tension being greater when reinforced is referred to, and the opposite contention given, but the confirmatory experiments of the French Commission and their limitations are not stated, so the reader is not directed on the right road, which we presume is the object of this record.

The shear strength of concrete is likewise left in a very unsatisfactory and inconclusive condition by the citing of various views and the comparative value of the experiments not being ascertainable from the information given. Of course, those who know a little of the subject will be able to appreciate the value, but to them the record is of no advantage—to those inquiring for the first time it is distinctly misleading and disconcerting, and such inadequate treatment deserves to be condemned in no measured terms. It almost makes one indignant that the Institution of Civil Engineers should have failed to realise that such a haphazard collection of facts arranged in an order which can only lead the casual reader to wrong conclusions must seriously affect its position with the members of the technical professions at home and abroad.

Again, in regard to bond or grip stresses between steel and concrete, the experiments recorded are not described in sufficient detail or in proper order, so that the casual reader cannot gain any true lesson from them. For instance, Prof. Withey's tests require the diagram showing how the test pieces were arranged, and then we can appreciate that his results are not in the same character as Bach's, which are not dealt with.

A very misleading classification of a few experiments on the breaking load of reinforced concrete beams, as compared with the calculated safe load and the factor of safety so obtained, is given. The original detailed records must be referred to in such cases, unless a very careful annotation is made by one who is constantly dealing with the design of such members. Thus the factor ranges from 12 to 2, but the low results were in most cases due to want of provision against shear or diagonal tension. Indeed, the beams were only experimental, and did not conform to the modern better nor even standard practice in actual structures. The beams referred to are rectangular, and in practice they are usually T-shaped. That ignoring of T-beams, of course, is an error that the pure theoretician, such as the professor and the inexperienced engineer often fall into.

The column tests recorded are equally badly dealt with.

ADDENDA TO THE EVIDENCE.

Secondly, as to the Addenda to Memorandum " G," as this is chiefly evidence of facts, we merely summarise the points of chief value.

INFORMATION FURNISHED BY MR. A. G. LYSTER, M.Inst.C.E.

Mr. A. G. Lyster, M.Inst.C.E., gave the following information upon works in reinforced concrete executed for the Mersey Docks and Harbour Board :

The following statement shows the cost of the repairs, etc., for the four oldest reinforced concrete structures built for the Board, and for two recently built :

—	Date of Erection.	Cost of Erection.	Amount since Spent on Repairs.
		£	£
Deck for cattle wharf, Prince's Jetty	1899–1900	4,800	160[1]
Floor or deck on Hennibique piles, Prince's Dock, west quay	1904–1906	12,700	75[2]
Floor for wharf, Coburg dock, north quay	1900	2,760	16[1]
Floor for wharf, etc., Brunswick half-tide dock ...	1901	740	5[1]
Floor for wharf, north quay, Brocklebank dock ...	1908	3,500	Nil[2]
Treble-story shed, south quay, Sandon dock ...	1908	32,700	[3]

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[1] Subject to the effects of moist air arising from the water below it.

[2] Deck subject to the effects of moist air ; piles more or less submerged according to the water-level.

[3] This shed is built entirely of reinforced concrete, including the foundation piles. It was first

INFORMATION FURNISHED BY MR. C. S. MEIK, M.Inst.C.E.

DESIGNS AND RESULTS IN PRACTICE.

Experience as to Effect of Use on Reinforced Concrete Structures.—In piers, wharves, and structures in the water suitable fendering should be provided to prevent the piles and other members from being subjected to blows or chafing from vessels lying alongside the structure, otherwise the concrete covering of the steelwork might be damaged and the water gain access to the steel. Experience also proves that extra precautions both as regards materials and workmanship require to be taken to ensure impervious concrete between wind and water, in order to prevent the water gaining access to the steel bars and causing them to corrode and crack the concrete covering. Where the concrete is always covered with water the risk of corrosion appears to be no greater than above the highest water line.

The pier at Purfleet has been run into by steamships on two occasions, and although the damage caused by the second collision was serious, costing nearly £2,000 to make good the defects, the repairs were carried out without any difficulty, and the work was made as good as before the accident.

Some improvement in the method of joining the tension bars in long members and the vertical bars in columns and piles is required, the present system of overlapping the bars and lashing them together with wire being defective. Experience gained from the collision of a steamer with the pier at Purfleet plainly showed that the joints of the vertical steel bars were the weakest parts in the piles supporting the pier. As regards the tension members of girders, when the length exceeds, say, 50 or 60 ft., efficient joints between the bars are necessary; these have not been as yet attained, and failing satisfactory welds screwed couplings are the only alternative.

In large surfaces of concrete expansion cracks are certain to happen, and either strong longitudinal reinforcement or else expansion joints become necessary. In the case of a large conduit of square section reinforced with expanded metal, but not specially reinforced longitudinally, expansion joints were inserted at 60-ft. intervals. Experience has shown that these should have been closer.

Extent of the Repairs and Reinforcements which have been found necessary since the Works were Completed.—With the exception of the pier at Purfleet, which was completed in 1904, the works carried out by the firm to which the writer belongs, have not been in use for a long enough period to enable one to say with confidence what the annual sum for maintenance will amount to. In the case of Purfleet pier, however (the reinforced concrete of which cost about £12,000) the cost of repair other than that due to collisions, has been about £10 per annum.

In the case of the first reinforced concrete structure with which writer was connected, the maximum stress on the concrete in beams and floors under working loads was limited to 600 lbs. per sq. in. This was increased to 700 lbs. per sq. in. in the case of the work at the King's Dock, Swansea, owing to the high class of concrete used, and the writer would not hesitate further to increase the limit to 800 lbs. per sq. in. for 1 : 4 concrete made of broken granite or trap-rock, suitably graded. In such a concrete the breaking stress under compression would be over 4,000 lbs. per sq. in. after 3 months. As a general rule, the concrete has not been permitted to take any of the tensile strains. The shearing stress was in all cases limited to 60 lb. per sq. in. for concrete and 6 tons per sq. in. for steel. The limit of stress on the steel for tension was 7½ tons per sq. in., and writer considers that this stress compares favourably with the stress of 6½ tons per sq. in. allowed for steel in tension

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brought into use on May 7th, 1908. Experience of its behaviour under ordinary working conditions has not, therefore, been long enough to provide much data for useful opinions. However, almost as soon as the work had been completed numerous small cracks revealed themselves in the floors, columns, and walls of the shed, especially in the thin panels of the walls between the columns. The specialists considered that the cracks were due to the shrinkage of the concrete. The contractors were called upon to repair them, and this was done, in the case of the large cracks, by cutting a chase about ½ in. deep on the line of the crack, and refilling, and in the case of the fine cracks outside the building, by grouting with a brush. In consequence of the appearance of these cracks the contractors' period of maintenance was extended for a further period of 6 months. The repairing of these cracks was estimated to cost the contractors about £450.

in steel girder bridges, having regard to the fact that in the former case the steel is effectually protected from corrosion, which cannot be avoided in the case of steel used in girders. In other words, the factor of safety of the steel in the concrete does not decrease with the age of the structure. As the strength of a reinforced beam depends more on the yield point or elastic limit of the steel than on its ultimate strength, writer is in favour of using high-tension steel for reinforcement, and if it were possible to obtain reliable material should specify for a yield point of at least 20 tons per sq. in. The writer sees no objection to using steel of this class, as it is not subjected to much working before being inserted in the concrete, very few of the bars requiring more than a slight setting or bending.

NOTES AS TO THE MANUFACTURE OF REINFORCED CONCRETE.

Experience has led the writer to adopt concrete made with broken stone, either granite, trap, or other hard rock, in preference to gravel or ballast flints. Tests made of 6-in. concrete cubes in the proportion of 1 : 1⅓ : 2⅔, with gravel and with broken granite respectively, in connection with the work at the King's Dock, Swansea, showed that at 6 months' age the former crushed at 2,453 lbs./in.^{2}, and the latter at 3,998 lbs./in.^{2} the weights being 131 lbs. and 149 lbs./ft.^{3} respectively. Had trap-rock been used in place of granite, the crushing stress would have been still higher, judging by experiments made at the Watertown Arsenal, U.S.A. The experience gained in driving the piles at both Purfleet and Swansea confirms this. At the former place the piles were made of cement and Thames ballast in the proportion of 1 : 4½, with a stronger mixture in the heads, and these heads frequently broke up where the driving became hard, the monkey weighing 2 tons, and falling through 4 ft. only. At Swansea, where cement, sand, and broken stone were used in the proportion of 1 : 1½ : 2⅔ the pile-heads remained intact throughout, although the monkey weighed 2½ tons, and was sometimes allowed to fall 10 ft. In both cases the specified set in the piles was the same—namely, 1 in. for ten blows with a 2-ton monkey falling through 4 ft.

The proportion of cement to other materials used in the work at Purfleet and Swansea varied from 1 : 1½ : 3½ for beams, etc., to 1 : 1⅔ : 2⅔ for piles, but by paying more attention to grading the broken stone, and consequently using a smaller proportion of sand, the cement could be reduced in amount without affecting the strength of the concrete.

The writer has always used concrete gauged with just sufficient water to enable it to be properly inserted into the moulds and between the bars, as he thinks it preferable for the concrete to be rammed into the moulds than to be allowed to flow in. Where joints occur with numerous interlacing bars in them a more fluid mixture is, of course, necessary.

High compressive strength in concrete for reinforced beams and columns is highly desirable, and this can be best attained by using broken granite, trap, or a dense millstone grit, and keeping the larger particles as large as is consistent with the interstices between the steel bars and the sides of the mould. The stone should be graded from a 1-in. mesh downwards to a ⅛-in. mesh, and no more sand than necessary should be used in order to obtain a mixture of the maximum density. From the experiments made at Swansea, which are confirmed by those made at Watertown Arsenal, the weights of the test specimens show that the increased strength of the concrete was due primarily to the density of the mixture, and it also appeared that in the case of a beam the increase of weight was more than compensated for by the increase in strength obtained. Thus, taking the foregoing Swansea tests, the increase in weight per cubic foot of the test specimens for gravel concrete over broken granite concrete was 14 per cent., while the increase in strength at 6 months amounted to 63 per cent.

The writer had numerous tests made recently of various concretes and has plotted curves showing how the compressive strength of the concrete rises progressively with the weight of the concrete, the mixture—proportion of cement to other materials—remaining the same throughout. They show that as the weight goes up per cu. ft. so does the strength. Thus concrete weighing 124/lb. ft.^{3} at 9 months stood a little over ½ ton/in.^{2}, whereas concrete that weighed 148 lb./ft.^{3} stood

2 tons/in.², or an increase of nearly 400 per cent. That was without adding any more cement to the mixture. The proportion remained the same throughout, 1 : 4, the difference in strength apparently being due to the increasing density of the concrete obtained by better mixing of materials. At one time the writer thought it was due to the crushed granite itself being superior to gravel, but from experiments* the writer does not think that has really much to do with it. It is more the density of the mixture. Provided one could get the same density by using gravel and sand that he got by using crushed granite and sand, the result would be the same.

With regard to the cost, the cement, of course, remains the same, and therefore as far as that is concerned the cost is the same. The blocks that stood the higher test were made of crushed granite, which costs more than gravel. The difference in cost between the minimum and maximum of those test blocks was only 3d. per cu. ft., the addition being due to using granite as against gravel. In Swansea the total cost per cu. ft. was over 6s., and for an extra 3d. per cu. ft. of reinforced concrete you get an increase in strength of the concrete of nearly 400 per cent. I make these remarks because I think it shows that in dealing with reinforced concrete we pay great attention to the steel, great attention to the cement and the materials of which the concrete is made, but we do not pay sufficient attention to mixing the concrete, which is a very critical point in this material

STATEMENT FURNISHED BY MR. BERTRAM BLOUNT, Assoc.Inst.C.E.

"There are two matters affecting the stability and permanence of reinforced concrete which appear to me to be of special importance.

"The first is the risk of destruction of the cement in the concrete and of corrosion of the steel constituting the reinforcement; the second the stresses due to expansion of the concrete and the steel, and to the difference in the value of the co-efficient for the two materials.

"The likelihood of attack of the cement itself depends on the same conditions as determine whether ordinary concrete—unreinforced—is attacked, but as the thickness of the concrete over the reinforcement is usually small it is evident that even more care must be bestowed on the avoidance of those conditions than in the case of concrete in large masses, where the surface of attack is relatively smaller. With regard to the steel, the risk of corrosion is primarily dependent on the continued access of water to the steel. Mere moisture left in the concrete after its preparation or any stationary water is of small consequence, because that water soon becomes saturated with lime, and forms an alkaline medium excellently adapted for the preservation of steel. But continued access of water involving anything approaching a flow of water will remove this preservative lime and cause the customary rusting of steel exposed to water. It follows that the concrete of armoured concrete must be practically impervious. This need for imperviousness has been recognised in practice by making the concrete rich in cement, but as far as I know no measurements of the permeability of the mixtures ordinarily employed have been published. Such experiments as I have carried out have been directed to a different end, and have been made with mixtures of cement and standard sand, and go to show that though at first pervious such mixtures soon become moderately water-tight. Similar experiments with concrete composed of cement, sand, and small stones, such as is ordinarily used for reinforced concrete, would be useful. Impermeability of reinforced concrete, whilst desirable in all cases, becomes of great importance in structures immersed in fresh water, and imperative for those in sea water.

"The co-efficient of expansion by heat of mild steel is well known, the figures generally accepted being 0·0000069 per degree Fahrenheit. That of concrete varies somewhat with the composition, but for a 1 : 2 : 4 mixture is usually taken at 0·0000055 per degree F. For a mixture of 1 of Portland cement to 1 of sand I have found 0·0000053 per degree F. wet and 0·0000073 per degree F. dry. These values are so similar that the stresses resulting from their difference is small. But the stresses due to the two materials regarded as a whole in a structure hindered from expansion may be considerable, and should certainly be computed in cases where the structure is exposed to a large range of temperature. Further, there are no data (so far as I have been able to ascertain) concerning the alteration of length of concrete which takes place by alternation of wetness and dryness. If this, as seems probable, is considerable, serious stresses may arise both in a structure not free to expand and between the concrete and its reinforcement. Experimental investigation of this question appears to me to be desirable."

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* *These will be dealt with in another issue.*—Ed.

EXAMPLES REPORTED UPON.

Thirdly, from Memorandum "H." we reproduce below abstracts from the reports on works executed :—

GREAT BRITAIN.

JETTY-HEAD AT THAMES HAVEN.

Report by E. W. HOLLINGWORTH, Assoc.M.Inst.C.E.

General Description.—The head of a T-jetty, constructed of timber and steel, and belonging to the London and Thames Haven Oil Wharves, Ltd., was damaged by a vessel and was reconstructed in reinforced concrete. The gangway was undamaged and was not altered.

The jetty is situated at a bend of the river, and, being on the outer bank, is exposed to a strong current. Vessels up to 10,000 tons are berthed, and the structure is therefore exposed to heavy blows, which the jetty-head is designed to withstand without assistance from the timber gangway. The deck is 5 ft. 6 in. above high water of spring tides, and 48 ft. above the river bed. The range of spring tides is 18 ft.

Age.—The work was commenced in February, 1907, and finished in March, 1909. The head was built in halves, the first half being used during the construction of the second half.

External Influences.—The work is exposed to the action of salt water, to alternate wetting and drying, and to blows from steamers.

General Condition.—The general condition of the structure is perfect; there are no signs of wear or deterioration on the portion which has been in use for a year.

Materials.

Composition of Concrete and Nature of Aggregate.—The aggregate was Thames ballast crushed to pass through a ¾-in. mesh, and sharp river sand, all carefully washed, and fresh water from a neighbouring well was used in mixing. The concrete was mixed in the proportion of 1 : 2 : 4 for the decking and beams and 1 : 1½ : 3 for the piles and columns.

Deterioration.—At one point there was a crack apparently due to the separation of two layers of concrete.

One of the struts had been cracked by a steamer, which ran into the jetty and a large piece was ready to spall off one edge, and one or two grooves had been worn in the coping by ropes, but otherwise there was no sign of wear or decay.

The surface of the lower part of the structure is being rapidly covered with green weed.

RESERVOIR AT NEWTON-LE-WILLOWS.

Report by E. W. HOLLINGWORTH, Assoc.M.Inst.C.E.

General Description.—The reservoir has a capacity of over 300,000 gals., and consists of a circular tank, 72 ft. in diameter and 14 ft. high, supported on twenty-eight columns 66 ft. high. This structure is the largest of its kind in the United Kingdom.

Age.—It was completed at the end of 1904.

External Influences.—The sides of the tank are exposed to the weather and the sun, to the difference of temperatures due to the water inside and the sun outside, and to constant saturation from the water.

General Condition.—A number of horizontal cracks have been formed, and the water weeps from them when under pressure.

Except for these horizontal cracks the structure appears to be in good condition.

Materials.

Composition of Concrete.—The concrete was mixed in the proportion of 6½ cwt. of cement to 13 cu. ft. of sand and 27 cu. ft. of whinstone gravel, under ¾ in. diameter, or about 1 : 4½. A slightly higher proportion of cement was used for the tank itself.

Tests of Concrete.—Compression tests on 4-in. cubes of the concrete showed an ultimate strength of from 2,400 to 4,300 lbs. per sq. in. at 1 month, and from 2,900 to 4,200 lbs. per sq. in. at 3 months.

Methods of Construction.

(a) Mixing the Concrete and Filling it into the Moulds.—The concrete was mixed by a machine to a consistency "the sloppy side of stiff," and about 20 minutes was allowed for getting it into position after mixing. It was placed in layers about 9 in. thick. The concreting of the walls of the tank was practically continuous, and was completed in 11 days. The horizontal struts were moulded on the ground and built into position when the columns reached the proper height.

The concrete was protected from the sun and kept damp for about a week after laying.

(b) Time Allowed Before the Removal of Moulds.—The shuttering was removed from the columns sometimes within half a day of concreting, moulds were removed from the struts in 2 days, but the centering of the floor and walls of the tank was left in position for a long time. The weather was very hot during the construction of the reservoir, the shade temperature being over 80°.

Loading Tests of Finished Work.—The tank was partially filled and emptied several times before it was filled to its full capacity, and leaks were discovered. The deflection was not observed. The cracks were first noticed after a frost which occurred when the tank was empty.

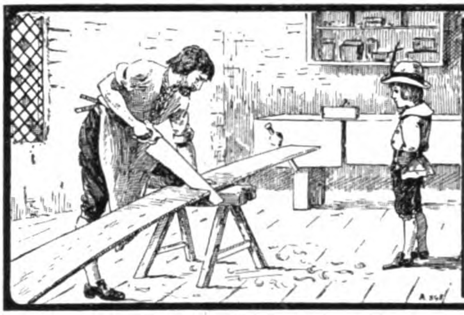
Failures or Deterioration.

(a) From Design and (b) from Materials or Construction.—The design of the structure appears to be somewhat light. The flat stirrups have rusted and caused the spalling off of the concrete cover in a large number of places; but this is also due to the displacement of the reinforcement during construction.

(c) From External Influences.—The walls of the tank have bulged in the middle to the extent of about ¼ in., and horizontal cracks have been formed all round the tank. The worst cracks are at the junction of the walls with the bottom of the tank, and about 1 ft. and 6 ft. above it. These cracks, through which the water weeps, are attributed to temperature stresses. The bulging is largely permanent, and has gradually increased during the past 2 years, but it is found to vary under a hot sun as well as under differences of pressure in the tank.

(To be continued.)

NOTE.—The tank is now (August, 1910) being relined with bitumen sheeting covered with an interior layer of reinforced concrete.



THE CONSTRUCTION OF CONCRETE FENCE POSTS

(*Conclusion*).

The use of reinforced concrete fence posts is making some headway even in this country, and several of the more enlightened chief engineers of railway companies have started to specify them freely, recognising their practicability and economy. Others, we trust, will soon follow suit.

The particulars given in this and our October number are taken from a bulletin issued by the U.S. Department of Agriculture.—ED.

REINFORCEMENT.

THE value of reinforcing concrete posts properly may readily be seen from *Fig.* 6. If a load (L) is raised so that its weight is supported on one side by a wooden post, the post will bend, as in *Fig.* 6. The fibre in the wood on the side away from the load may be tough and elastic enough to prevent the post from breaking, and when released the post will spring back into its former position. In the third figure a No. 9 wire (W) is fastened securely to the wooden post at the top and at the ground surface, and is supported along its length by the struts (S). If the same load is applied, the post will not bend, because the wire takes up the bending or stretching strain. This is precisely the case with the reinforcement in a concrete post. Supported along its length by the concrete, the wire (W) or steel in other shapes takes up the bending or stretching strains. Since the load which causes bending or stretching may come from any direction, concrete posts are reinforced on every side; otherwise they might break in a manner somewhat similar to that in which the wooden post bends when the reinforcement is not on the proper side of the post.

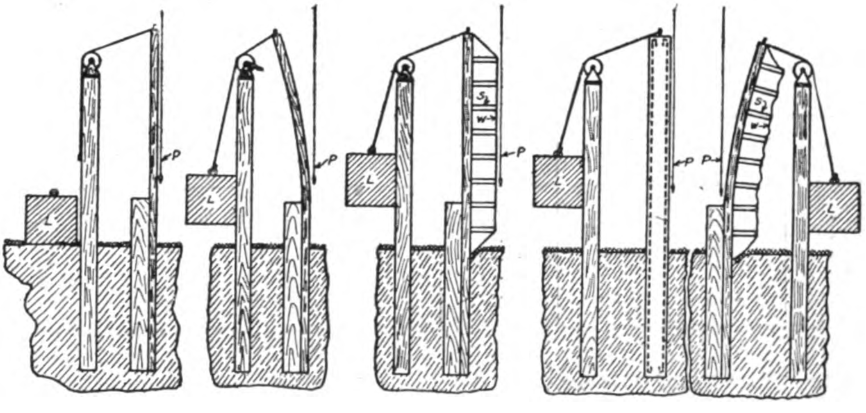


FIG. 6. SHOWING EFFECT OF REINFORCEMENT.

In the effort to be safe it is a common fault to insert more reinforcement than is absolutely necessary. This adds needlessly to the cost of the post, for concrete posts become stronger as they grow older.

Kinds of Reinforcement.—With regard to the roughness of the outside, metallic reinforcing materials are divided into two classes, smooth and corrugated or deformed. The general result of the many tests carried on in testing laboratories seems to indicate that in strength of bond, if the concrete is sufficiently rich and well mixed, smooth surfaces give satisfactory results. Two kinds of reinforcement are much used—bars and wire.

Bars.—Round bars three-sixteenths or one-fourth of an inch in diameter are the size and kind most used in posts. The stock on hand at blacksmith shops and hardware stores is generally from steel that stretches too easily and therefore is not the best for reinforcement. Companies which make a speciality of reinforcing materials can furnish both rods and bars which stretch only under very large loads.

Wire.—The development of the wire fence has produced a material well suited for reinforcing purposes. Of equal size, such wire will produce a stronger post than the material described above. Single No. 8 or two No. 12 wires twisted are sufficiently strong as reinforcement for ordinary line posts. In order to obtain straight wire of the necessary length, the coils ordinarily placed on the market should not be straightened out. Straight wire can be obtained from dealers in the same manner as baling wire; that is, either single or twisted into two or three ply cables and of the length desired. The plain, ungalvanized fencing wire is the proper kind, for galvanization adds nothing to the strength and the metal will not rust when incased in the concrete.

The following table will be convenient in determining the size and weight of wire desired for reinforcement or for other uses:

Sizes and Weights of Wire.

Gauge.	Feet to lb.	Gauge.	Feet to lb.	Gauge.	Feet to lb.	Gauge.	Feet to lb.
1	4·68	6	10·17	11	25·82	16	95·98
2	5·44	7	11·97	12	33·69	17	128·6
3	6·31	8	14·29	13	44·78	18	166·2
4	7·38	9	17·05	14	58·58	19	223
5	8·75	10	20·57	15	72·32	20	309·6

The "Fool-proof" Spacer.—In order that the reinforcement may be placed and kept just where it belongs, there is in use a little device called the "fool-proof" spacer. It consists of a No. 10 wire, cut to such length that, when twisted once around each of the two reinforcing wires or rods, the ends will nearly touch the sides of the mould (*Fig.* 7). The distance from the twist to the end of the short wire is equal to the distance from the reinforcement to the side of the mould. In triangular moulds such a spacer can be used only on the two rods or wires near the top of the mould. A shorter and similar device, with only one twist, may be used on the lower reinforcement. At least three spacers should be placed on each piece of reinforcement.

Spacers on No. 8 wire, which should be placed three-fourths of an inch from the inside of the mould, should be made from the following lengths of wire for the various sizes of triangular posts:

LENGTH OF WIRE FOR SPACER (IN INCHES) FOR TRIANGULAR POSTS.

—	Heavy Posts.	Medium Posts.	Light Posts.
Upper spacer ...	6½	6⅛	5¼
Lower spacer] ...	2	2	1⅞

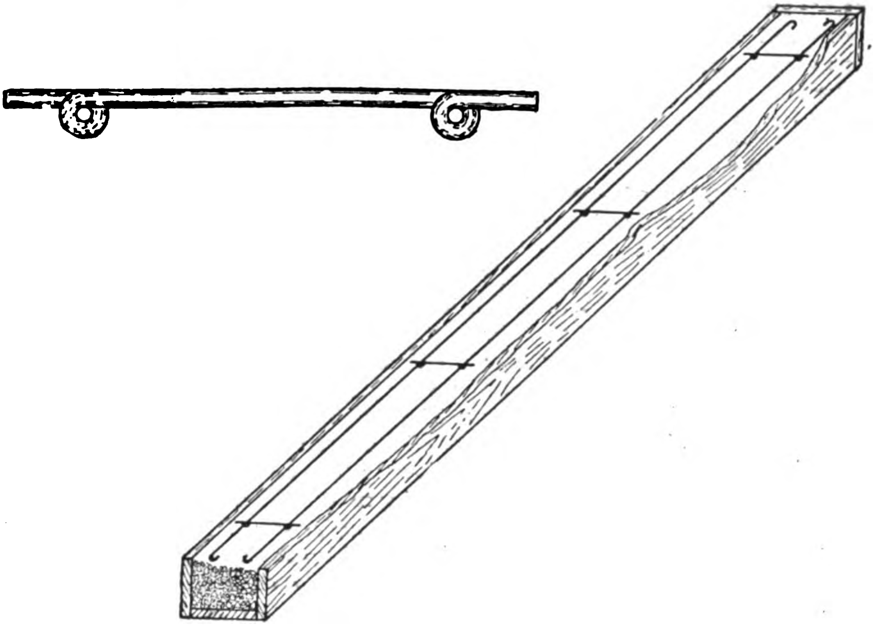


FIG. 7. "FOOL-PROOF" SPACER FOR REINFORCEMENT.

Spacers on No. 8 wire for various sizes of square, or nearly square, posts should be made from the following lengths of wire :

LENGTH OF WIRE FOR SPACER (IN INCHES) FOR SQUARE POSTS.

—	Straight Posts— 5 by 5.	Posts Tapering on Two Sides— 4½ by 6, 4½ by 4½.	Posts Tapering on Four Sides— 5 by 6, 4 by 3.
Bottom spacer ...	5¾	6⅜	6⅜
Middle spacer...	5¾	6	5¾
Top spacer ...	5⅞	5¼	4⅜

For larger or smaller reinforcing a little additional length may be added or deducted. When the proper length has been determined, a number of spacers should be prepared and slipped on the reinforcing iron by way of preparation for placing it in the mould. This serves to hasten the work.

General Remarks.—Reinforcing should be placed near the outside wall, where it is reasonable to expect that cracks will open. For reinforcement metal slightly rusted is as good as metal that is not rusted, if not better. In placing the reinforcing rods in position it is a wise precaution to bend them back at the ends (*Fig.* 7). This takes only a little more time, but if it is done the reinforcement must be 2 in. longer to allow the metal to be turned back 1 in. at each end of the post. New barbed wire should not be purchased for reinforcement, for while it costs more than plain reinforcement, the bond between it and the concrete is no stronger than between smooth wire and concrete. The danger section, or the point where posts are liable to break, is at the surface of the ground. For fences for lots and other places where posts may be subject to rubbing and crowding, short extra reinforcing pieces 2 ft. long are sometimes placed in the post to lap this danger section. The corner of triangular-shaped posts which is not nearest the fence wire should, in theory, have heavier reinforcement than either of the other corners. If rods three-sixteenths of an inch in diameter, No. 8 wire, or two twisted No. 12 wires, are used in the other corners, a rod one-fourth of an inch in diameter, or two or three twisted No. 12 wires, should be placed in the threatened corner.

MIXING THE CONCRETE

The Mixing Board.—The size of the mixing board depends on the number of men employed in this work and on the amount of room available for placing the board in position. Sometimes a tight and even floor in a building may be used. The steel sheet from the platform of an old self-binder may be used for a mixing board, but the larger the board the more convenient it is. For two men mixing, the board should be 8 ft. by 12 ft.; for four men, 14 ft. by 14 ft. The first size is usually large enough for making posts. It should be built of matched inch boards, free from knots, drawn tightly together and placed the short way of the platform, so that the mixers may shovel with the cracks and not against them. The framework should consist of four scantlings, 2 in. by 4 in., laid the long way, and with the two outside ones of sufficient length to afford handles for carrying. The location for the board should be fixed before the sand, stone, and gravel are unloaded. A level spot with sufficient open space convenient to the work, and, if possible, near the water supply, should be chosen. Much hard labour can be saved by locating the mixing board lower than the water tank and by siphoning the water through a garden hose to a barrel or other receptacle at the mixing board. The board should be raised on blocks until it is level, so that under the weight of concrete it will not sag in the middle. If water is added gradually, as it should be, there will be little liquid grouting to run. It is best, however, to nail a 2-in. by 2-in. strip or a piece of 2-in. by 4-in. scantling around the edges of the board.

Runways. — If, in wheeling the materials, runways are necessary, they should be built so that they will be smooth and strong. Should the runs be over 2 ft. above the ground, 20 in. is none too great for their width. The speed of the work depends upon the rate of moving the materials and concrete.

Tools.— One great advantage in using concrete is that it can be made with the investment of very little money in special tools. If the few required are not already at hand for other purposes, the new ones will serve in many different lines after the concrete is finished. For mixing, it is necessary to have from two to four square-pointed, short-handled "paddy" shovels, size No. 3. A couple of wheelbarrows with steel trays, and with a capacity of 2 cu. ft., are convenient for moving the sand, stone, and concrete. If wooden moulds are used, a metallic sidewalk "edger," with a curve of three-eighths of an inch in the radius, will make neat corners. A corner trowel, or even an ordinary trowel, will answer the same purpose fairly well. Screens may be made by nailing ¼-in. and ⅛-in. mesh wire screening, 2½ ft. by 5 ft., to frames made of 2-in. by 4-in. lumber.

The Measuring Box.—Since construction with concrete is so easy, many persons are careless about the exact proportions of the cement, sand, and gravel or crushed rock to be used in its composition, but this is a very important point. The bottomless box with handles attached is a very useful article for this purpose. For posts, a convenient measuring unit is a box with an open bottom 12 in. by 14⅜ in. and 10 in. deep, measured on the inside. This box, filled to the top with the loose material and smoothed level, contains practically 1 cu. ft. The inches in height may be marked with brass tacks. Then, since each inch in height represents one-tenth of a cubic foot, the measurements are easy. If, on account of its size, the use of this box would be too slow for measuring the sand and gravel, larger boxes or wheelbarrows may be gauged and used, or other boxes may be made on the same principle. It is a very poor practice to count shovelfuls, as it produces unsatisfactory and even dangerous results.

Making a Six-Post Batch.—The following table gives approximate quantities for a batch of concrete sufficiently large to make six posts 7 ft. long and of the sizes named in the table. The quantities may be increased in like proportion and any desired number of posts may be made. The first of the two lines of figures given for each of the three grades, heavy, medium, and light, indicates the proportions to be used when the sand is screened from the gravel. The second line gives the proportions when "bank-run" gravel is used; that is, gravel dug directly from a bank without screening the sand. In this case 1 part of cement to 4 parts of the mixture of sand and gravel should be used.

QUANTITIES OF MATERIAL AND RESULTING AMOUNT OF CONCRETE FOR A SIX-POST BATCH.

Triangular Posts—Length, 7 feet.

Size of Post.	Proportions of Materials by Parts, Measured in Volume.			Materials in Cubic Feet, Measured Loose.			Concrete Tamped, Cubic Feet.	Water for Mixing, Gallons.
	Cement.	Sand.	Gravel or Rock.	Cement.	Sand.	Stone or Gravel		
Heavy	1	2	4	1·4	2·8	5·6	6·2	11
	1	—	4	1·5	—	6·0	6·2	11
Medium... ...	1	2	4	1·3	2·6	5·2	5·5	10
	1	—	4	1·4	—	5·6	5·5	10
Light	1	2	4	1·1	2·2	4·4	4·8	9
	1	—	4	1·2	—	4·8	4·8	9
Rectangular Posts—Length, 7 feet.								
Straight, 5 by 5	1	2	4	1·7	3·4	6·8	7·3	13
	1	—	4	1·8	—	7·2	7·3	13
Taper on two sides, 4½ by 6, 4½ by 4½	1	2	4	1·6	3·2	6·4	6·9	12
	1	—	4	1·7	—	6·8	6·9	12
Full taper, 5 by 6 4 by 3 ...	1	2	4	1·5	3·0	6·0	6·7	12
	1	—	4	1·6	—	6·4	6·7	12

Proportioning the Ingredients.—On account of the variations in the size of the sand grains and in the unfilled spaces between the particles of sand, stone, and gravel, the quantities of concrete made according to the proportions above may be greater or less than those stated in the tables. For the same reason the quantities of water may or may not be sufficient to make the concrete wet enough. Such matters, with the experience gained through making a few batches, may be easily adjusted. Water should always be measured by the bucket to have uniform results.

Different pockets of sand and gravel and different "crusher-run" rock vary in size and consequently in the unfilled spaces or voids between the grains or pieces. This variation, in theory, calls for varying quantities of cement, but the methods of determining the exact amount of these unfilled spaces are so complicated and so open to mistakes that, with cement at its present low price, it is cheapest in the long run to adopt proportions or mixtures which are rich enough to guarantee a well-made, strong post. If unscreened "bank-run" gravel is decided upon, it should be used in the proportion of 1 part of cement to 4 parts of gravel. For crushed rock or screened gravel (which is much better than "bank-run" gravel), the concrete should be used in the proportion of 1 part of cement, 2 parts of sand, and 4 parts of rock or gravel. All measurements should be made with the material poured loosely into the measuring box, and the box, when full, should be levelled smooth.

The amount of moisture in the sand, gravel, and stone varies so much with weather conditions that the quantity of water for a cubic foot of concrete cannot be fixed exactly. During the mixing of the cement with the sand and rock sufficient water should be used for the concrete to be wet enough, when the mixing is complete, to tremble under a blow from the shovel and to run into the moulds. This amount of water causes a rich mortar to flow to the outside of the post and insures a smooth finish. A force pump and hose afford a convenient means of conveying water to the work. Often by locating the mixing board lower than the water tank water may be siphoned through a garden hose to the board.

Mixing "Bank-run" Gravel.—For concrete from unscreened "bank-run" gravel, one-half of the amount of gravel required for a batch of posts should be spread out in oblong shape; and upon this should be evenly distributed, first the full amount of cement, and then the remainder of the gravel. Two men facing each other and at the same end of the batch (and, if necessary, two at the other end), with square-pointed "paddy" shovels, turn the dry cement and gravel with a "flopping," dragging stroke. By timing their strokes, the mixers can cause their shovels to meet regularly at the middle, which insures the complete mixing of all the materials. For a thoroughly mixed concrete, no definite number of turnings can be fixed, but the shovelling should be continued until the cement no longer shows in streaks or until the mixture has a uniform colour. Skilful concrete turners do not lift the shovel from the board and "flop" over its contents as though they were turning "flapjacks," but by gradually turning the shovel and at the same time dragging the stroke they completely mix the dry cement and gravel in two turnings. When the scattered materials around the edges have been thrown upon the pile it is cut open and, using a sprinkler—a sprinkler bucket or a hose with spray attachment—about three-fourths of the water required is added. Water dashed from buckets or from the ordinary nozzle of a hose causes a waste of cement. The mixture is again turned and cut open as before. Then the remaining one-fourth of the water is added and the mixture is turned again. With careful workmen the concrete should now be well mixed, but if it shows dry spots it must be turned once more. After this the concrete should be shovelled into a compact ridge, ready to be wheeled away to the moulds or to be shovelled into them. The mixing board should be thoroughly cleaned at the close of each day's work. Persons who intend to make the manufacture of posts a business will do well to invest in a good power mixer.

Mixing Crushed Rock or Screened Gravel.—In general, where crushed rock or screened gravel is used, the mixing is very similar to that of "bank-run" gravel. The full amount of sand is spread out upon the board and upon it the necessary cement is evenly distributed. The whole is turned dry until the cement no longer shows in streaks and the colour of the batch is uniform. The mixture is then spread out flat, just as the sand was, and upon it the crushed rock or screened gravel is distributed evenly. Three-fourths of the required water is added and the mixing is continued as for mixing "bank-run" gravel. In dry, hot weather it is a good plan to throw water on the pile of crushed rock before mixing.

CONCRETE POSTS.

Moulding.—After the moulds, which, as a rule, lie flat, have been oiled or soaped, the concrete should be placed in them at once. If, for any reason, the concrete stands thirty minutes after mixing, it should be thrown away and a new batch mixed, for cement, if it has once partially set, makes weak, dangerous concrete, even though it is retempered by turning or adding water. After the moulds are filled evenly to the depth of three-fourths of an inch or 1 in., according to the spacing of the reinforcing rods or wires, the reinforcement should be laid in, properly spaced by means of at least three "fool-proof" wire spacers. The concrete should then be poured in until the moulds are filled within three-fourths of an inch or 1 in. of the top, when the remaining reinforcement is fitted in place in the manner described above and the moulds are completely filled. To render the concrete more compact a crowbar or a pinch bar should be placed under each corner of the mould successively and moved up and down quickly. This vibration makes the concrete more compact by shaking out the air bubbles, but there will be very few of these bubbles if the concrete is sufficiently mixed to proper consistency. If desired, the exposed corners of the post may be bevelled with an "edger," and the open face given a neat finish by using a trowel immediately after the surface water has been absorbed and before the concrete has become too hard.

If wooden moulds are used they should be well soaked in water, so that the green concrete will not cause them to swell and thus crack the posts.

The wind, the hot sunshine, and the frost are destructive to concrete; and while it is an easy matter to protect the post from the first two agents, it is best to do no concrete work when the thermometer is below the freezing point, unless inside a building.

Curing.—It is a great mistake to believe that when the moulding is done a concrete post is finished. The quality of the post must be determined by curing. The green post should be left in the mould until thoroughly hardened; that is, usually for two or three days. For square or nearly square posts the moulds proper may then be removed and used on another bottom board, but the posts must stay on their bottom board in the shade and must not be disturbed for at least a week or ten days. Posts in triangular moulds may be carried out, each in its own mould, after from five to seven days, and the post may be gently slid from its mould to a smooth floor covered evenly with a cushion of sand. While green the strain of lifting, or even a slight jar, will cause cracks, sometimes invisible, which greatly weaken the post. During the first two days of the life of a post it must be kept wet and covered with canvas, burlap, carpet, or any clean material. Sand will serve after the concrete has become hard, but manure will stain green concrete and otherwise affect it. The sprinkling should be continued up to the eighth day. After the tenth day, if the space is needed, the post may, with care, be placed on end in the same manner that wooden fence rails were formerly piled. A drop of only 6 inches often breaks a green post. The jar in hauling to the field over rough, frozen roads or in a wagon bed with a very uneven bottom has seriously injured posts which were not well seasoned. Concrete posts gain rapidly in strength for the period of one year; they should, therefore, be made as long as possible before it is necessary to set them in the fence. No post should be used until it is at least 3 months old, and, to meet any contingency, a supply of well-seasoned posts should be kept on hand.

BUILDING THE FENCE.

Setting the Posts.— Experience has taught that, with regard to stringers and joists, in order to get the greatest strength from the timber, one should place the beam with the narrow side against the load and with the depth extending in the same direction as the pressure. Likewise, posts should be placed so that the narrow side will support the wire. This will give the greatest resistance to breakage from animals rubbing against them or trying to get through the fence between the posts. The depth to which posts should be set varies with the character of the soil. Seven-foot posts are usually set from 2½ ft. to 2 ft. 8 in. deep. The earth about the post should be thoroughly compacted by tamping.

Methods of Attaching Wire.—There are numerous methods of attaching wire fencing to concrete posts. Some makers place staples or wire loops in the green concrete; others make holes in the posts. The former method is not desirable because the fastener cannot be located exactly where the wire of the fencing will come when the post is set in the ground; then, too, the fastener will eventually rust or break off and will thus injure the looks of the post. On the other hand, holes through the posts weaken them and therefore this method is, in general, unsatisfactory.

The simplest, easiest, and cheapest way of fastening a wire fence to a concrete post is by encircling the post with a wire one size less than the corresponding wire in the fence proper and by twisting this wire around the strand of the fence. This is done in two ways. The fastening wire is placed around the post, twisted upon itself and then to the fence wire; or one end of the fastening wire is twisted around the fence wire, and the free end is then carried around the post and twisted on the other side to the same wire. (*Fig.* 8.) The latter method is known as "the Western Union twist." Either plan is good, but care must be taken to draw the fastening wire tight, or else stock trying to get through the fence may raise or crush down the fencing with their heads. If any trouble is experienced the post should be roughened at the fastening point with a cold chisel.

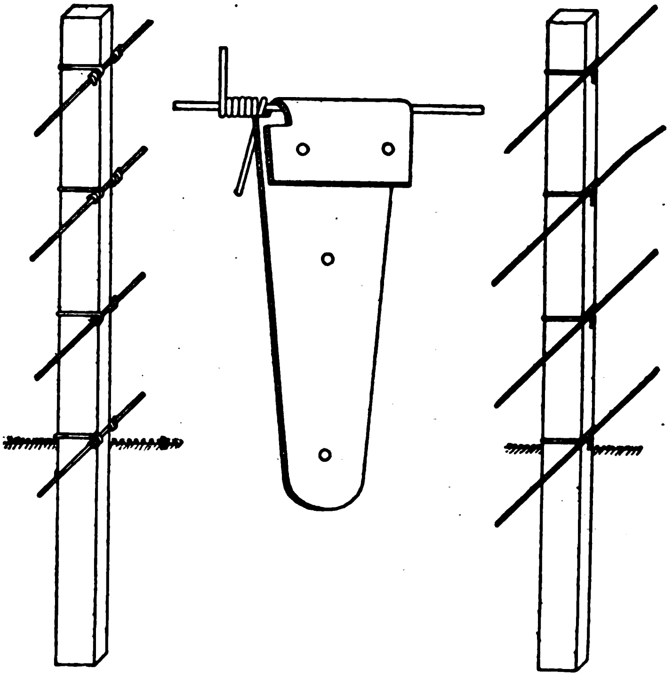


Fig. 8. Method of Attaching Fence Wire to Concrete Posts.

Expansion and contraction of the fence due to heat and cold are cared for by the tension curves or "kinks" in the woven-wire fencing, and no fear may be felt in drawing the fastening wires as tight as necessary. Wooden nailing strips should never be embedded in the posts, for moisture will swell the wood and crack the concrete.

Stretching the Fencing.—Good tools for stretching wire fencing may be found in almost any fence company's catalogue. Stretchers should be such as to be easily operated by one man. They usually consist of two heavy chains, one of which is fastened to a post at the corner or brace in the fence and the other by means of a large hook to the wooden clamp which holds the loose fencing. The stretcher proper, operated by a lever, is the connecting link between the chains. By working the lever back and forth, dogs reach out, grasp, and draw in link after link of the chain, and thus tighten the fence. The best stretchers are also automatic in releasing the wire. Owing to the great force used in stretching fencing, it is advisable from the standpoint of safety to purchase stretchers with automatic releases. There are many good automatic single-wire stretchers on the market.

Line Anchors.—Concrete posts, by their weight, serve to hold fences down in the gullies of hill country. Sometimes in such places and occasionally under other conditions the wire fencing must by some means be staked to the ground to prevent small animals from going under it. This may be accomplished either by digging a hole under the fence, filling it with concrete, and embedding a tie wire in the concrete, or by burying a block of concrete around which the tie wire has been placed. After the concrete has set the fence may be made secure by attaching the tie wire to the heavy lower wire of the fencing.

Cost of Concrete Posts.—So many elements enter into the matter of cost that no exact figure can be given. The prices of labour, moulds, cement, sand, stone, gravel, reinforcement, and lumber are not the same in any two sections of the country. The cost of only two sizes of post will be considered here—the heavy, triangular and the straight, square post, each of which has a standard length of 7 ft. The figures are based on the following data : A mixture of 1 part of cement, 2 parts of sand, and 4 parts of crushed rock or screened gravel; a reinforcement consisting of two No. 12 smooth fencing wires twisted into a cable and cut to the necessary length at the factory; concrete mixed by hand; all materials delivered at the work, and all labour of men and teams paid for.

With the heavy, triangular post, if considered necessary, a slightly heavier reinforcement may be used in the corner of the post away from the fence.

COST OF MATERIALS AND LABOUR AND OF THE FINISHED POSTS.

Heavy, Triangular Posts.

Materials.	Cost.	Number of Posts.	Cost per Post.
1 yd. of rock or gravel	$1·00 (4.2d.)	29	$0·03½ (1¾d.)
1 yd. of sand	1·00 (4.2d.)	58	0·1¾ (1d.)
1 barrel (4 sacks) of cement	1·50 (6.3d.)	18	0·08½ (4¼d.)
3 two-ply No. 12 wire cables (weight, 1¾ lb.)	0·02½* (1¼d.)	1	0·04¼ (2¼d.)
2 men for one hour, at 20 cents per hour ...	0·40 (1.10d.)	5	0·11 (5½d.)
1 boy for one hour, at 15 cents per hour ...	0·15 (7½d.)		
Total cost	—	—	0·29 (1.2¾d.)

Straight, Square Posts.

Materials.	Cost.	Number of Posts.	Cost per Post.
1 yd. of rock or gravel	$1·00 (4.2d.)	25	$0·04 (2d.
1 yd. of sand	1·00 (4.2d.)	50	0·02 (1d.))
1 barrel (4 sacks) of cement	1·50 (6.3d.)	16	0·09½ (4¾d.
4 two-ply No. 12 wire cables (weight, 2¼ lb.)	0·02½* (1¼d.)	1	0·05¾ (2¾d.)
2 men for one hour, at 20 cents per hour ...	0·40 (1.10d.)	5	0·11 (5½)
1 boy for one hour, at 15 cents per hour ...	0·15 (7½d.)		
Total cost	—	—	0·32¼ (1.4d.)

* Per pound.

Since the straight, square post is slightly larger than the heavy, triangular, it costs a little more.

MISCELLANEOUS POSTS WHICH MAY BE MADE OF CONCRETE.

Concrete posts are used for many other purposes than line posts. The sizes are slightly different, but the principles and general lines of design are the same.

Corner Posts.—Corner posts are generally made with square ends, 8 in. by 8 in., 10 in. by 10 in., or 10 in. by 12 in., and without taper. Heavier reinforcement is used and should be increased in amount by placing extra pieces on all four sides either at the middle or one-third points. The wire may be drawn around the post or holes may be made through it by placing greased iron rods at the proper places in the green concrete and turning them about occasionally so that the concrete will not set to them. A short piece of pipe may be placed through the mould and left in the post in order to provide a hole. Through these holes the strands of wire may be stretched and some tightening device may then be used. The post should be thoroughly cured before being strained by holding a tightly stretched fence.

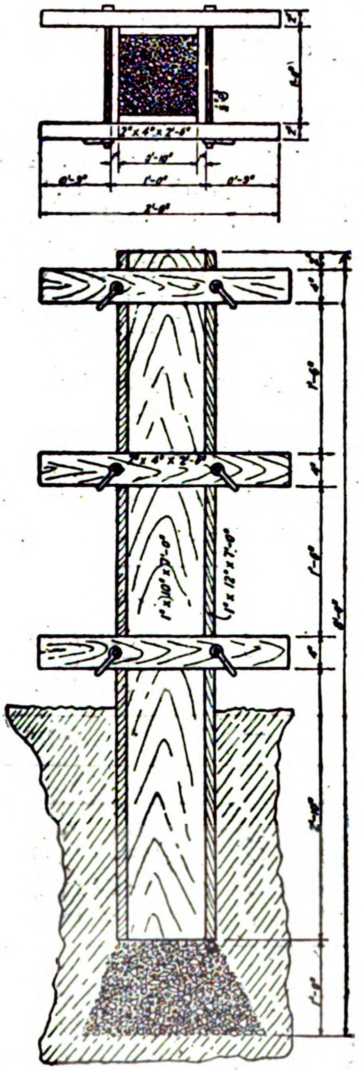


Fig. 9. Method of Constructing Bracket for Bracing Posts.

Bracing Posts and Braces.—Bracing posts should be placed frequently in the fence line. A mortise for inserting a brace may be made in the upper end by temporarily placing a block of the desired dimensions in the green post. This operation requires considerable skill to prevent ruining the post. Some persons prefer making an offset or bracket (*Fig.* 9) on the post. Others mould the post and brace together at the same time.

Braces are made and reinforced like line posts. The ends must be moulded to a bevel in order to fit the offset or bracket in the post. The wire brace is commonly used, but sudden strains are liable to crack the top of the line post to which the wire is fastened. Another brace between the first and second line posts and slanting in the same direction as the concrete brace will remove such danger. A mass of concrete run around the ground end of the brace will fix it securely.

Gate Posts and Hitching Posts.—Gate posts are made in the same manner as corner posts. Hanging is accomplished by using a hinge with a clamp strap which entirely encircles the post. Fasteners are attached in the same way. Holes for bolt hinges are sometimes made in the post during the moulding. Large iron washers should then be placed between the post and the nut. If a hole is desired for a fastener, the hole should first be made by inserting a piece of gas pipe in the green concrete.

Hitching posts are merely line posts. Wrought-iron clamp straps make better attachments for holding the rings than holes through the post, which weaken it.

Vineyard and Arbour Posts.—As plenty of gravel is usually found in sections where grapes are grown, concrete posts are very convenient in the culture of grapes. A light line post will serve the purpose. If wire or an iron piece is not used to support the vines, an offset or bracket should be made on the post to hold the cross arm. The cross arm may also be made of concrete. Some growers prefer to erect a light line fence, using smooth wire from post to post as a means of supporting the vines.

Arbour posts are constructed in the same manner as vineyard posts. The skeleton work may also be made of concrete.

THE CHOICE OF REINFORCEMENT.

A Further Contribution by a Third Correspondent.

The choice of a suitable reinforcement in reinforced concrete work is a matter of the utmost importance, and the present contribution on the subject calls for attention.

Views on the subject are still very divergent, and those associated with the sale of special forms of bars are apt to take an optimistic view of the value of their particular specialities.

In our August issue (page 552) we published an article of the optimistic character referred to, and whilst intimating that we did not associate ourselves with the views expressed—either for or against—we opened our columns to those who have something to say on the subject. Both our issues of September and October contained contributions, and a further correspondent enters the lists below: several other contributions have been held over for lack of space. In our next issue we shall close the subject for the time being.—ED.

THE choice of a reinforcement is a matter which must depend upon the exigencies of the problem in hand, the engineer deciding for himself the requirements of his particular construction. The entire theory of reinforced concrete depends upon the steel and concrete working in unison without any slipping between them, and therefore the question as to whether or not the round rod has sufficient bonding power when embedded in the concrete is of primary importance.

The term " mechanical bond " is only a relative one ; for example, the ordinary round rod may be considered a mechanical bond bar when compared with a cold rolled tool steel bar, the former not being as true as the latter owing to the different processes of manufacture ; and this has been proved by actual tests.

One would have thought that the many thousands of constructions successfully carried out with ordinary round rods would give sufficient evidence that such reinforcement was a suitable one, but two of the correspondents in CONCRETE AND CONSTRUCTIONAL ENGINEERING take a different view. One of their arguments is that the cracks developed by plain bar reinforcement are greater than those developed by mechanical bond reinforcement. The feeble attempt made by the first correspondent to prove this is far from convincing. In truth, his statement, if correct, would go to show that the boot is on the other foot, and that mechanical bond bars develop larger cracks than plain rods.

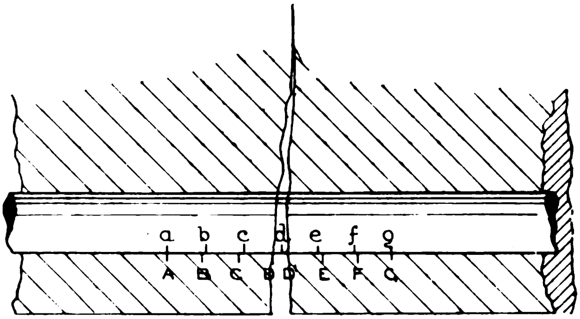


FIG. 1. DIAGRAM OF CRACK IN REINFORCED CONCRETE.

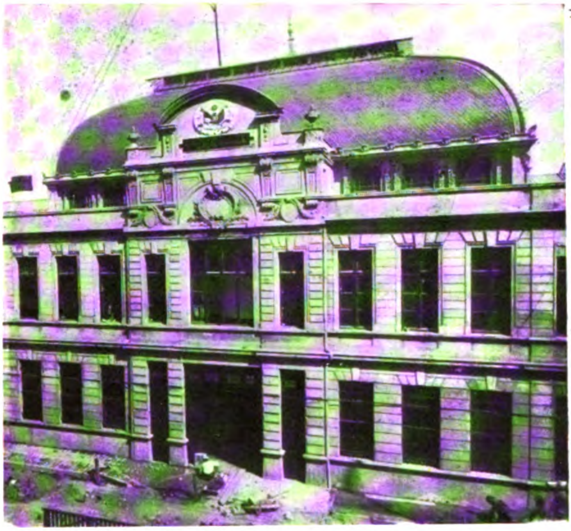
Without admitting the correctness of his statements let us follow his line of argument. Referring to his diagram (*Fig.* 1) no slip is assumed to occur at the two points A and G, and the width of the crack D D′, due to the extension of the steel, is necessarily proportional to the length A G. If there is no slipping at the points A and G, the concrete being locked in at these points by deformities on the bar, then the crack D D′, as stated before, depends upon the distance A G. Now, supposing plain bar reinforcement is used. When the beam deflects and the steel stretches, B moves away from b, C from c, D from d, etc. Therefore, if the concrete is free to act, a crack will occur at B, at C, at D, etc., but the size of those cracks will be much smaller than the crack D D′, which must be the summation or resultant crack of all the smaller ones. Thus, following his line of argument we see that plain rods will develop smaller cracks than mechanical bond bars. As previously stated, however, the correctness of your correspondent's statements was only assumed for argument's sake. As a matter of fact, the writer disagrees with his statements, and contends that there will be no difference in the size of cracks whether plain or mechanical bond bars are used, so long as both forms of bars are made of the same grade of steel. The size of cracks is independent of the bond, but depends entirely upon the quality of the steel. The reason why mechanical bond bars develop larger cracks than plain rounds, as is found to be the case in tests, lies in the fact that mechanical bond bars are made of high tensile steel, which is not suitable for reinforced concrete work. This subject is very ably discussed in Marsh & Dunn's handbook, 1909 edition, page 159.

Referring to Mr. Vawdrey's remarks, it would hardly be fair for the writer to occupy so much of your space as would result in the replies his communication justifies, for he is as much at sea as your first correspondent. Let us examine only one of his arguments. He claims that in fishtailing and splitting the ends of round rods, it is admitted that mechanical bond is necessary throughout the entire length of the bar. How can he possibly believe this is true ? Has he forgotten the results of reinforced concrete beams in their early stage of development ? Originally beams were reinforced with horizontal bars only. Such beams, when tested to destruction, showed the first signs of failure by the end concrete suddenly bursting away from the beam. Originally, engineers thought this was due to the slipping of the reinforcement, and then took the precaution of bending up, or otherwise anchoring the bars. Later, it was definitely proved that such failure was not due to the slipping of the reinforcement, but due to internal shearing stresses which were maximum immediately around the reinforcement over the supports, and then decided upon using vertical shear members distributed throughout the beam. They took the further precaution of anchoring the shear members as well at their upper ends, but this the writer claims an unnecessary step. That the horizontal shearing force is greatest around the steel over the supports, and causes this preliminary failure, is shown by the spacing of rivets in a uniformly loaded built up girder, where the end rivets are always spaced closer together than the centre rivets. For Mr. Vawdrey's special benefit, let it be said that the same kind of failure may take place even if indented bars are used horizontally only ; that indented bars prevent this kind of failure no more than plain round rods, and that it is just as necessary to fishtail, split, or otherwise anchor indented bars at their ends as round rods. Mr. Vawdrey will reply that they do not use horizontal reinforcement only, but bend up their bars at the ends to take care of shear. So do engineers who use plain round rods. He will reply that they do not fishtail or split their bars ; there is no reason why they should not.

The anchoring of round rods at their ends is not a recognition of the necessity for mechanical bond throughout the whole length of the bar, and it is surprising that Mr. Vawdrey should infer such to be the case.

So far as the economy in the use of high tensile steel is concerned, space will not allow of a detailed discussion in this communication. Suffice it to say for the time being that it is not nearly so great as its advocates would lead us to believe.

In summing up, I would say that for reinforcement the round rod is just as efficient as the mechanical bond bar, and is certainly a much more economical form of reinforcement.

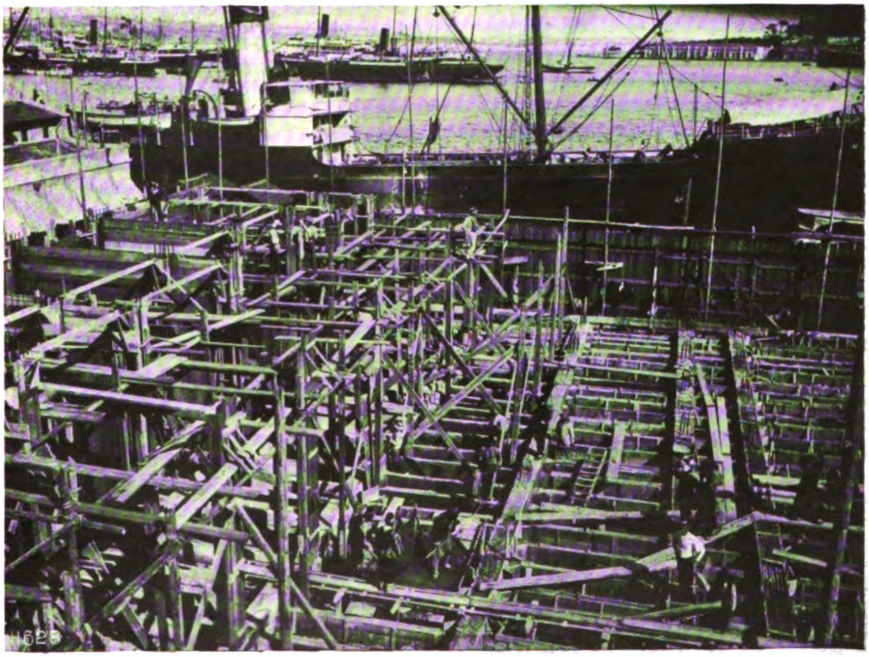


REINFORCED CONCRETE BUILDINGS IN CONSTANTINOPLE.

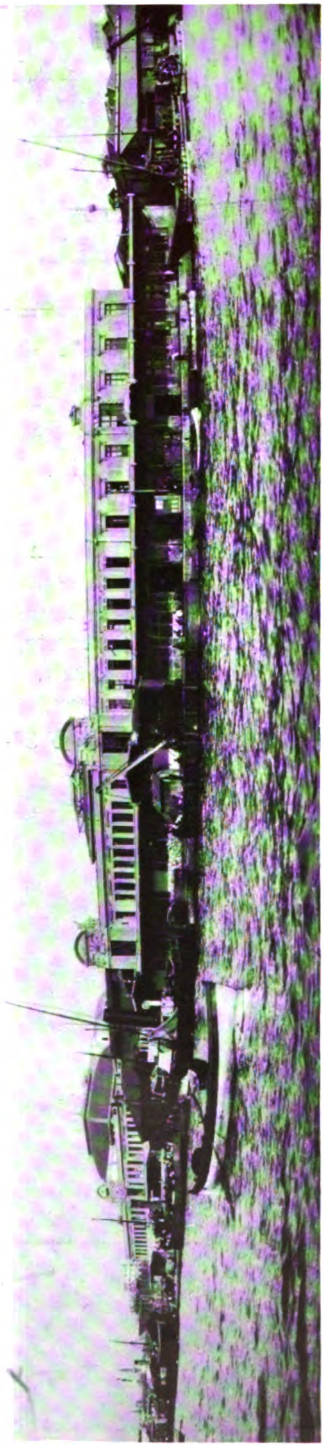
The uses to which reinforced concrete is being put in Turkey should claim the attention of British contractors, for there is a large field for the material in that country, especially at the moment. —ED.

THE sheds and Customs' offices described in this article are situated on both sides of the Golden Horn, facing one another—one at Galata and the other at Stamboul. They were erected for the Société Ottomane des Quais, Docks et Entrepots de Constantinople. The work is carried out entirely in reinforced concrete, including the walls, and the buildings are erected on a reinforced concrete raft.

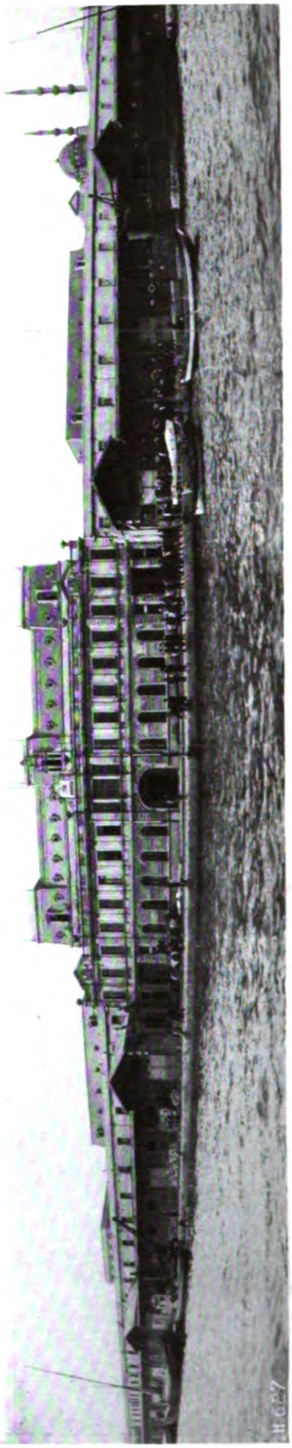
The company had reclaimed from the sea a large area of ground, and the problem of erecting structures on this made ground which, to a very great depth



Foundations of buildings at Galata.
REINFORCED CONCRETE BUILDINGS AT CONSTANTINOPLE.

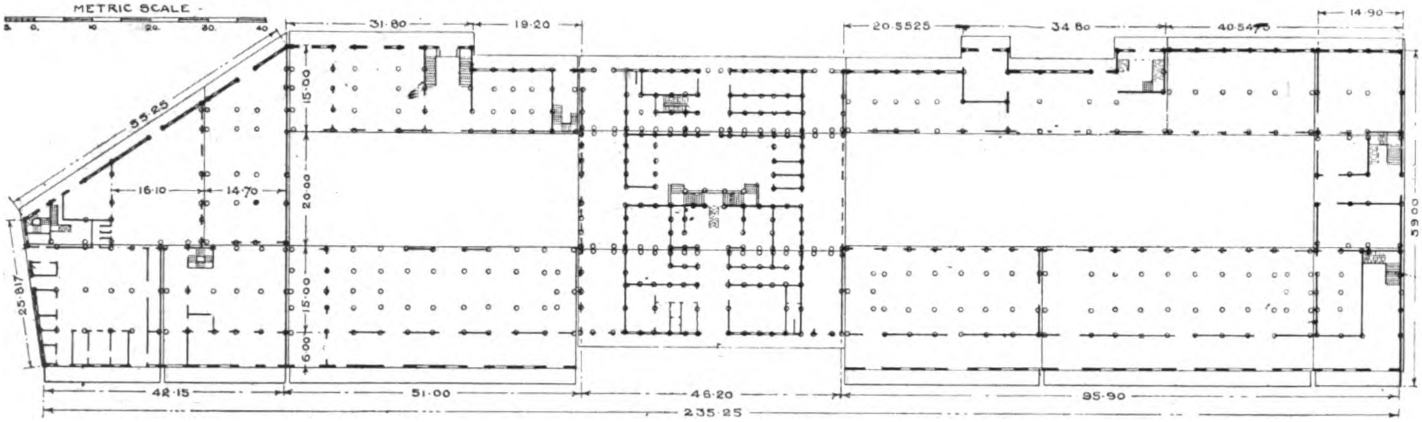


Customs' offices and sheds, Galata.

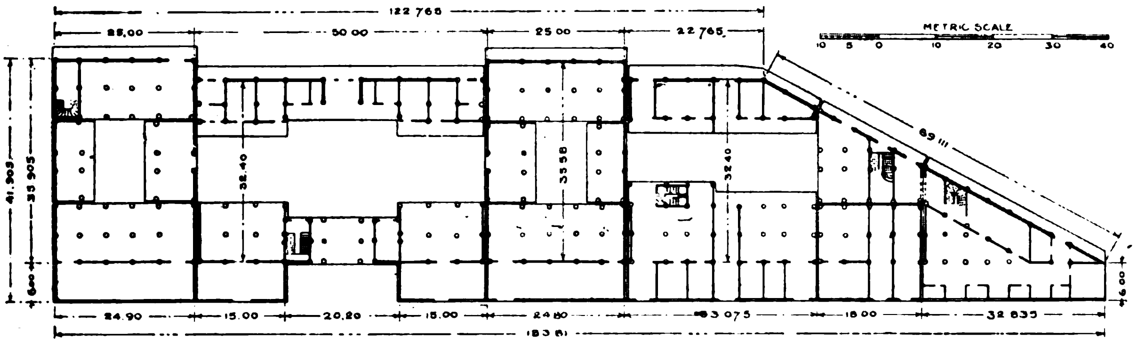


Customs' offices and sheds, Stamboul.

REINFORCED CONCRETE BUILDINGS, CONSTANTINOPLE.

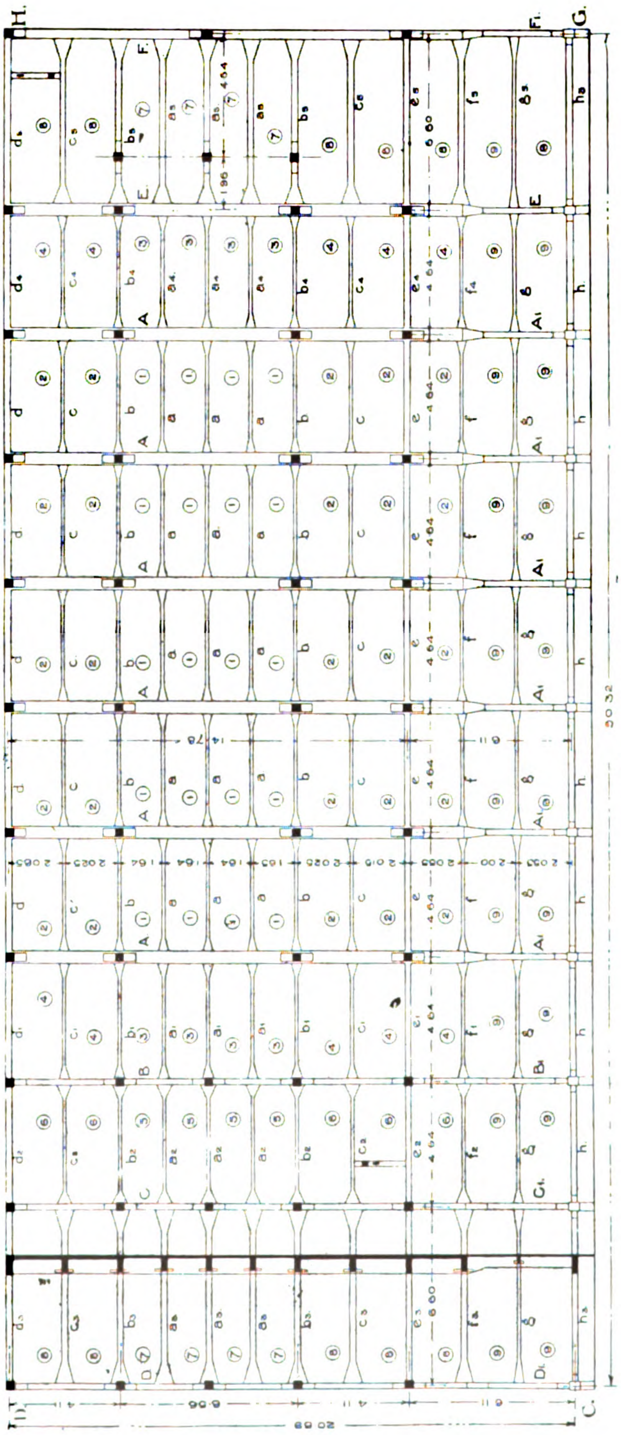


Plan of buildings, Stamboul.

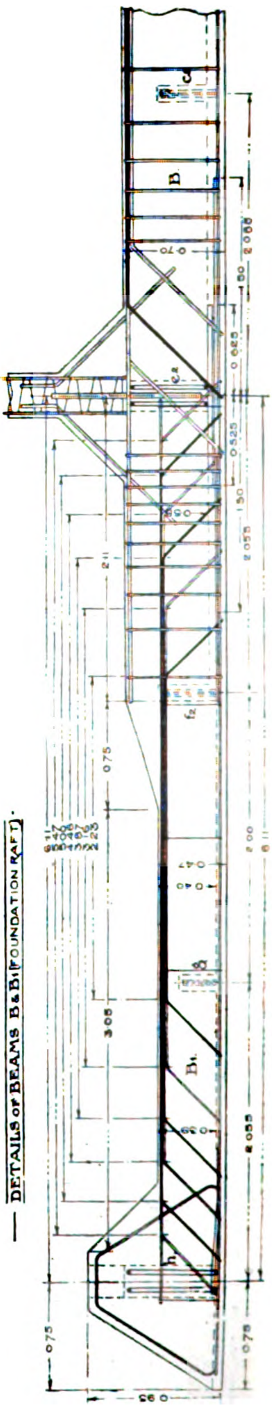


Plan of buildings at Galata.

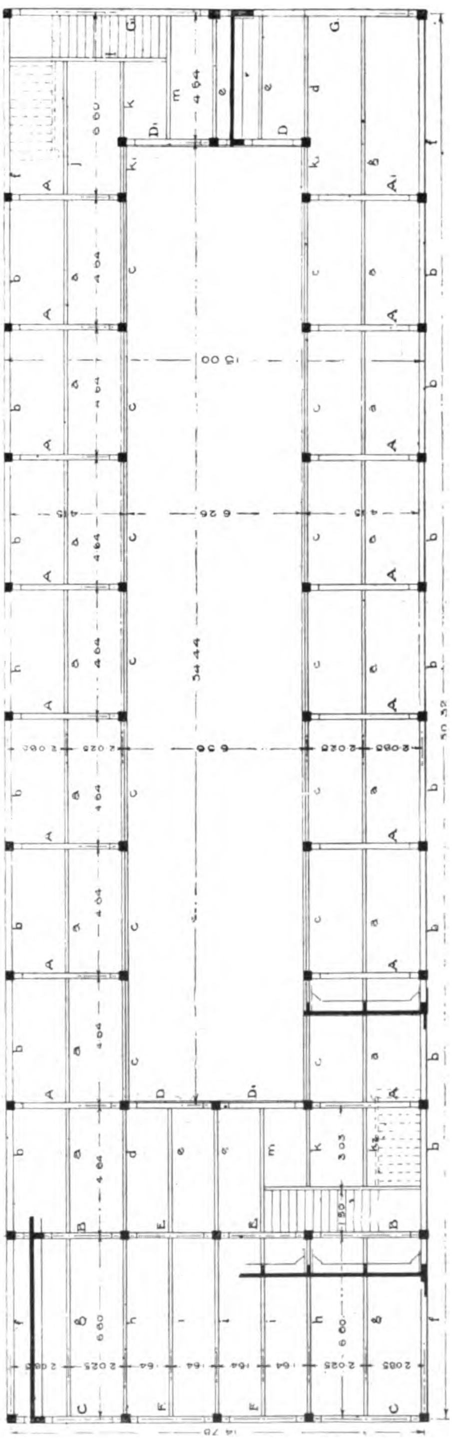
Reinforced Concrete Buildings, Constantinople.



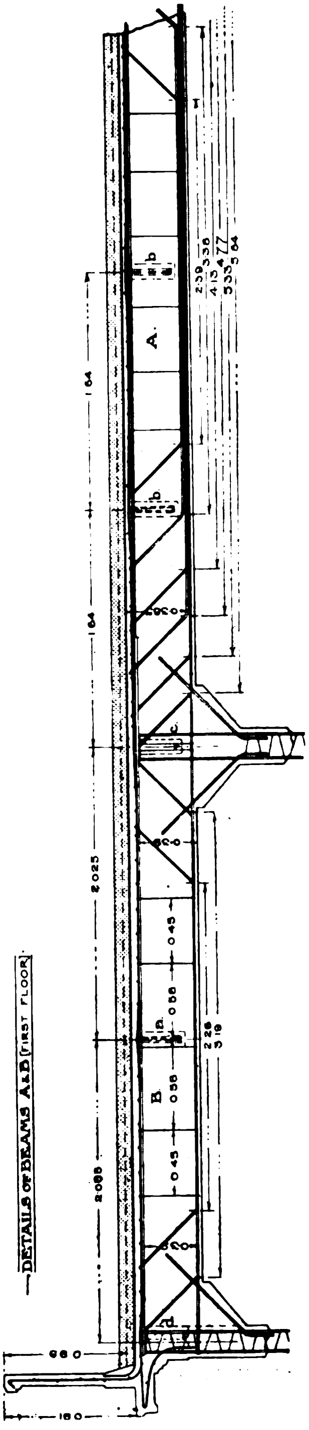
Plan of foundation raft.



Details of beams, foundation raft.



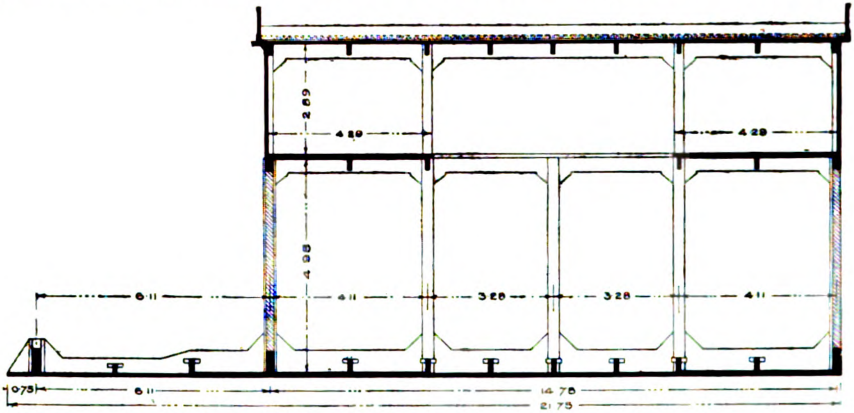
Plan of first floor from underneath.



Details of beams A and B, first floor.
REINFORCED CONCRETE BUILDINGS, CONSTANTINOPLE.

was composed of mud, was a difficult one. Piling was out of the question, owing to the inconsistent nature of the ground to a very considerable depth.

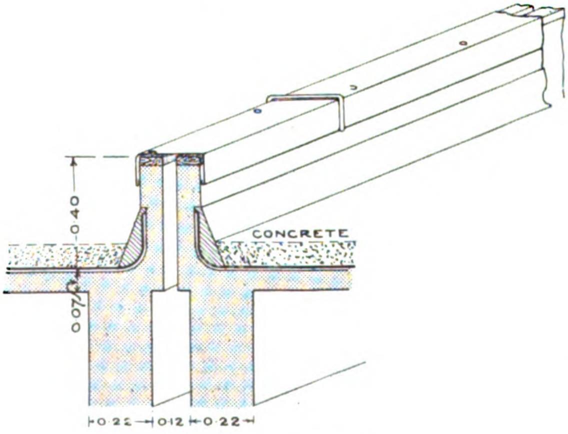
Mr. Edmond Coignet solved the difficulty by the use of reinforced concrete. A general raft was made, on which these heavy buildings were erected in such a manner that the entire structure, which is monolithic, may be said to be floating on the surface of the ground. Mr. Sabouroux, Engineer-in-chief to the Turkish company, also gave considerable help in the matter.



Transverse section, first floor, on C—D.

Reinforced concrete is extremely well adapted to this class of work, especially on account of its fire-resisting qualities. As the work is monolithic it affords great resistance to earthquake shocks, which is a matter of importance in Eastern countries.

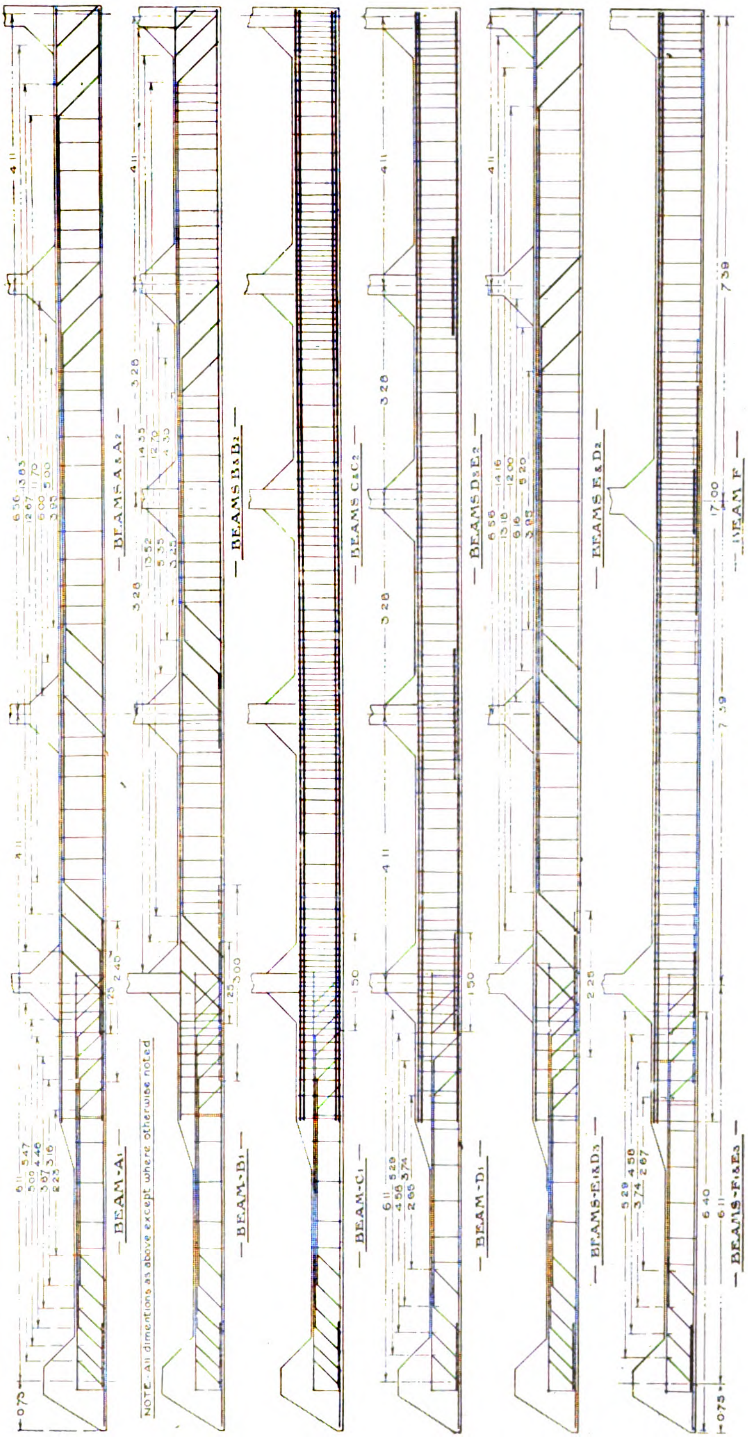
The buildings are all made in separate blocks. This is to allow for expansion and contraction, as it was thought unwise to make this long length of buildings in one piece. An illustration of one of the expansion joints in the roof is shown in adjoining illustration.



Expansion joint in roof.

The Stamboul Customs rest on a raft 240 metres (792 ft.) in length by 59 metres (205 ft.) wide. This raft supports nineteen buildings, all made of reinforced concrete. The largest of these buildings, without any expansion joint, measures 50 metres (165 ft.) in length.

The buildings, as shown in the illustrations, are built in parallel lines to the quay wall. The first line, fronting the quay, is composed mostly of buildings



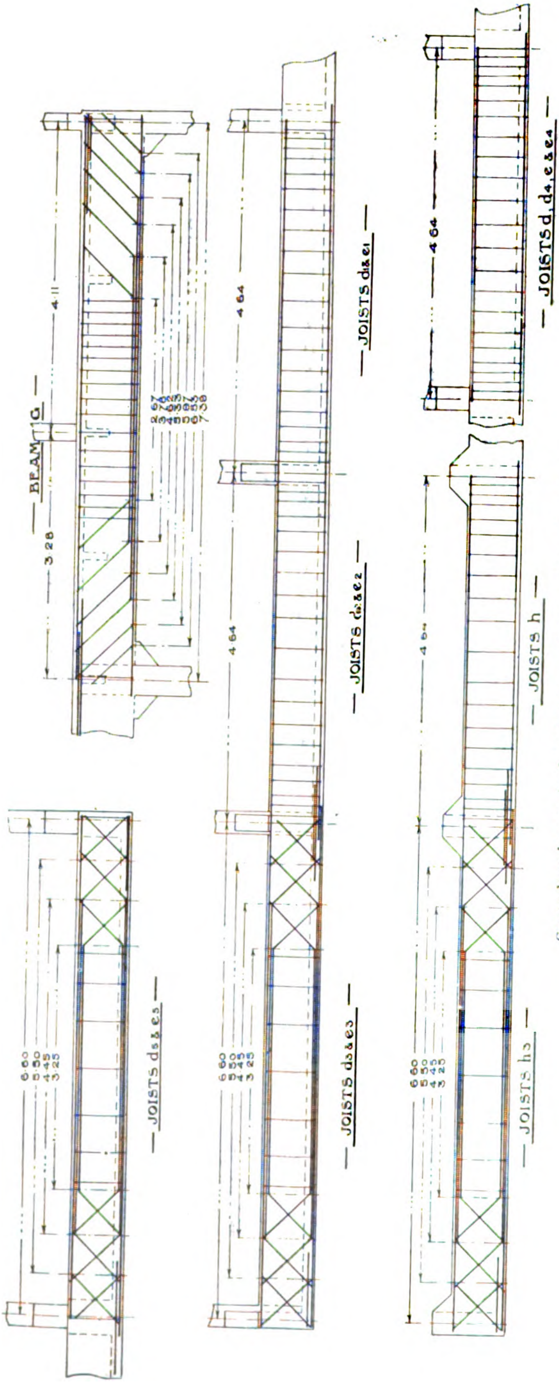
Details of beams.
Reinforced Concrete Buildings, Constantinople.

or sheds one storey high. The second line, at the back of these, has two storeys, and the third line three storeys.

The difficulty was to spread evenly upon the ground the varying weights of these buildings at a rate not exceeding 0·375 kilos. per sq. c/m. As explained before, it was possible to do this by making a foundation raft. In order to reduce the weights coming upon this raft, the walls of all the buildings were made in reinforced concrete in the manner of very thin panels of only about 4 in. in thickness. A thin brick partition was provided, however, in the interior, leaving an air space between the external reinforced concrete wall and this brick panel.

This novel method of constructing a wall with the outside face in reinforced concrete and an interior brick panel with an air space, had also the advantage of being a most excellent means of providing against external changes of temperature.

The Custom houses at Galata have a total length of 184 metres (607 ft.), and a width of 41 metres (135 ft.). They have been constructed on the same principle as the other buildings above described.



Secondary beams in foundations, and beam G on first floor.

TESTS OF REINFORCED CONCRETE COLUMNS SUBJECTED TO REPEATED AND ECCENTRIC LOADS.

By MORTON O. WITHEY.

We have pleasure in again publishing an article on important tests with reinforced concrete carried out in the United States, the present instance being taken from a paper read before the American Society for Testing Materials on June 30th, 1910.

AMONG some of the interesting tests carried on at the Materials Testing Laboratory of the University of Wisconsin during the past year, are those made on some very strong spirally-reinforced concrete columns. This paper reports some of the results obtained from tests of twelve of these columns.

The materials used in fabricating the test pieces will now be considered. A local crushed limestone screened to pass a 1¼-in. mesh and having the dust removed was used in making the concrete. It weighed 80 lbs. per cu. ft., and contained 52 per cent. void. A well-graded clean sand, weighing 107 lbs. per cu. ft., and containing 36 per cent. voids, was furnished from a pit near Janesville, Wisconsin. Tests on the cement, made in accordance with the standard specifications of the American Society for Testing Materials, showed it to be satisfactory. Table I. contains data derived from tension tests of the steel employed.

Concrete or mortar was proportioned by volume, measured loose, cement being assumed to weigh 100 lbs. per cu. ft. Volumes were measured by weighing. After the materials had been mixed dry for about one-half minute in a No. 0 Smith batch-mixer, about 10 per cent. of water, based upon the total weight of dry materials, was added through pipes leading to the mouth and hopper of the mixer. Three minutes of mixing was sufficient to furnish a homogeneous wet concrete which would flow around the reinforcement.

The general characteristics of the columns are given in Table II. As it was thought desirable to study the properties of the columns within the spiral, the galvanized iron moulds were fitted very closely to the spiral, so that there was only a thin shell of concrete encasing the metal. No account of this shell has been made in any of the computations which follow.

TABLE I.—TENSION TESTS OF STEEL USED IN COLUMNS.

Number of Tests.	Approx. Size of Bar, ins.	Area, sq. ins.	Stress at Yield Point, lbs. per sq. in.			Ultimate Strength, lbs. per sq. in.		
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
31	7/8	0·586	39,400	34,700	37,400	66,700	61,100	64,330
2	7/8	0·614	41,500	41,200	41,350	61,000	58,500	59,750
16	1/2	0·1964	40,600	37,000	39,670	60,300	55,000	57,800
8	11/16	0·3755	38,600	35,100	37,200	58,200	55,000	56,300
12*	3/16	0·0255	83,000	72,000	78,400	122,000	110,000	115,400

* Tests on No. 7 high-carbon steel wire from spirals.

In making the columns the longitudinal rods were spaced at equal distances apart and wired to the inner circumference of the spiral to prevent displacement in pouring. The forms, with the reinforcement inside, were then set upon planed cast-iron bed-plates which were carefully levelled before the columns were poured. One compression cylinder, 6 ins. in diameter and 18 ins. long, was cast in an iron mould from every batch of concrete. A day or two after pouring the columns and cylinders were capped with a thin layer of 1 : 1 mortar. While the mortar was still soft a cast-iron bed-plate was placed upon it and carefully levelled, care being taken to see that the depth of the mortar over the ends of the vertical reinforcement was made as small as possible. After six days the forms were removed from the specimens, which were then wet twice a day for one week and then sprinkled once a week until tested.

TABLE II.—PROPERTIES OF COLUMNS TESTED.

All columns 8½ ft. long and 10¼ to 10½ in. in diameter; 1 per cent. spiral reinforcement of No. 7 high-carbon steel wire, 1-in. pitch.

Col. No.	Longitudinal Reinforcement.	Long. Reinforcement, per cent.	Total Area Inside of Spiral (A), sq. ins.	Proportions.	Age at Test, months.	Kind of Loading.
X1	None	0	82·6	1 : 1½ : 3½	2	Repeated.
X2	„	0	84·6	„	2	Repeated and constant.
Y1	8 ⅞-in. round rods	5·7	84·6	„	2	Repeated.
Y2	„ „	5·8	82·6	„	2	Constant and repeated.
AA1	8 ½-in. round rods	1·9	84·6	1 : 1½	2 5	Central. Eccentric.
AA2	„ „	1·9	84·6	„	2 5	Central. Eccentric.
AB1	8 11/16-in. round rods	3·6	82·6	„	2 5	Central, repeated. Eccentric.
AB2	„ „	3·5	84·6	„	2 5	Central, repeated. Eccentric.
AC1	8 ⅞-in. round rods	5·8	82·6	„	2 5	Central. Eccentric.
AC2	„ „	5·6	86·6	„	2 5	Central, repeated. Eccentric.
AD1	„ „	5·7	84·6	„	5	Eccentric.
AD2	„ „	5·6	86·6	„	5	Eccentric.

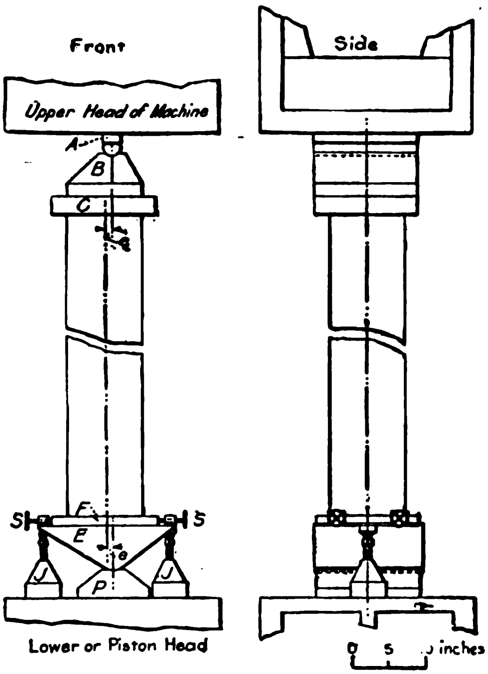


FIG. 1. ECCENTRIC LOAD APPARATUS.

The columns were tested in the 600,000 lb. hydraulic testing machine in the laboratory. The lower head of this machine is rigidly fixed to the piston rod of a hydraulic jack, while the upper head is free to adjust itself to the specimen through a ball and socket-joint. The columns were bedded at each end on cast-iron plates covered with a thickness of blotting paper.

In making the eccentric loading tests, the upper adjustable head was replaced by blocks A, B, and C, shown in *Fig.* 1. These blocks were held in place, while the column was being adjusted in position, by a cradle not shown in the figure. Before putting the column in the machine the vertical line on the block P was placed in a plane half-way between the uprights, and the top surfaces of the blocks E and F were held approximately horizontal by means of the jacks J. The column was then swung in place and plumbed by the jacks. The plate F supporting the column was then moved by means of the screws S until measurements between the sides of the machine and the column indicated that the desired amount of eccentricity of the load had been made. After adjusting the eccentricity, the piston head of the machine was raised until the column just supported the top blocks A, B, and C. These blocks were then adjusted so that the line on A was co-planar with the line on P. A small load was then applied and the jacks removed. In this manner the load was always applied axially with respect to the machine, while its eccentricity with respect to the column could be readily changed at the will of the operator.

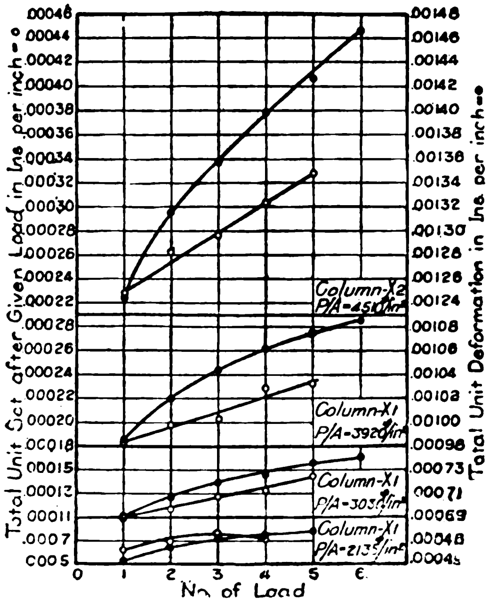


FIG. 2. SET REPETITION AND DEFORMATION REPETITION CURVES FOR COLUMNS X1 AND X2.

Stresses were applied at the rate of approximately 500 lbs. per sq. in. per minute. The increments of load differed with the kind of column and the method of testing. In general, when the load was being progressively increased, the increments were either 15,000 lbs. or 30,000 lbs. Measurements of longitudinal and lateral deformations were made with the same copper-wire dial compressometers and collar device, respectively, which were described last year. In the time-loading tests, changes of temperature in the room probably affected the results, but from the small change in thermometer readings and the fact that the wire was insulated, it does not seem necessary to make any correction in the dial readings. When eccentric loading tests were being made, especial care was taken to note the positions of all wires with reference to the column, as this is of vital importance if an accurate computation of the deformations at various points in the cross-section of the column is to be obtained.

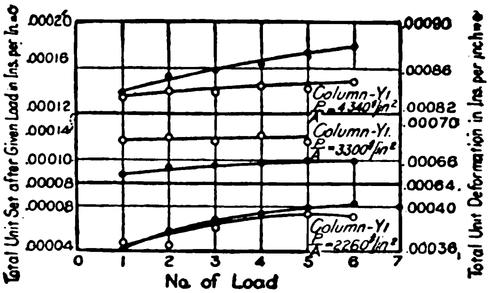


FIG. 3. SET REPETITION AND DEFORMATION REPETITION CURVES FOR COLUMN Y1.

Table III. contains data on the strength of columns subjected to repeated or time loadings. The main tests under these conditions were made on Columns X1, X2, Y1, and Y2. The other columns were not built to be tested in this way, but owing to their high strength it was found impossible to crush them in the ordinary manner, so repetition and time loadings were resorted to as shown. They are placed in this table to show briefly how they were tested before being subjected to eccentric loadings. Stresses in the steel were obtained by multiplying the deformations per unit of length by 30,000,000 lbs. per sq. in., the assumed modulus for the steel.

Fig. 2 shows several sets of curves drawn for Columns X1 and X2, with the number of repetitions as abscissæ and the deformations and sets as ordinates. The value of P/A, which was repeated, is indicated in each portion of the figure. In *Fig.* 3 similar sets of curves have been drawn for Column Y1. *Fig.* 4 contains deformation-time curves for Columns X2 and Y2, for values of P/A of 4,510 lbs. per sq. in., and 6,230 lbs. per sq. in., respectively. The breaks in the continuity of the curve for Column X2 are due to the fact that the loading was stopped twice, as indicated in Division 3 of Table III. After the first application for 30 minutes, the load was released and reapplied two days later for a period of 3½ hours. It was then released for 1½ hours and applied again for 4 hours. Subsequently the column was continuously loaded, until it failed at the load indicated in Division 7 of Table III.

TABLE III.—DATA ON STRENGTH OF COLUMNS SUBJECTED TO REPEATED OR TIME LOADINGS.
Loads are arranged in the order of their application.

Col. No.	No. of Repetitions of Stress.	Duration of Loads, minutes.	Average Unit-Stress. (P/A), lbs. per sq. in.	Unit Stresses at First Application of P/A, lbs. per sq. in.		Maximum Applied Load, lbs.	Ultimate Strength, lbs. per sq. in.	Compressive Strength of Cylinders, lbs. per sq. in.
				In Vertical Steel.	In Concrete.			
1	2	3	4	5	6	7	8	9
X1	3	—	2,135	—	2,135	—	—	—
	4	—	3,030	—	3,030	—	—	—
	4	—	3,920	—	3,920	—	—	—
	—	—	—	—	—	523,000	6,330	4,650
X2	4	—	4,510	—	4,510	—	—	—
	—	30	4,510	—	4,510	—	—	—
	—	210	4,510	—	4,510	—	—	—
	—	240	4,510	—	4,510	—	—	—
	—	—	—	—	—	500,000	5,900	4,665
Y1	5	—	2,260	10,800	1,750	—	—	—
	2	—	3,300	18,000	2,420	—	—	—
	4	—	3,300	—	—	—	—	—
	5	—	4,340	25,100	3,090	—	—	—
	4	—	7,300	*—	—	—	—	—
	—	—	—	—	—	617,500	7,300	4,220
Y2	—	90	6,230	35,900	4,390	—	—	—
	3	—	7,480	*—	—	—	—	—
	—	—	—	—	—	617,509	7,480	4,120
AA1	—	5	7,300	*—	—	617,500	Not broken	6,135
AA2	—	15	7,300	*—	—	617,500	,,	7,440
AB1	—	25	7,480	*—	—	617,500	,,	6,340
	1	4	7,480	—	—	—	,,	—
AB2	—	20	7,300	*—	—	617,500	,,	6,435
	1	16	7,300	*—	—	—	,,	—
AC1	—	26	7,480	*—	—	617,500	,,	6,075
AC2	—	20	7,140	*—	—	617,500	,,	5,835
	2	—	7,140	—	—	—	,,	—

* Beyond yield point. A few small cracks along the spacing bars were visible on columns AA1–AC2.

As it was found impossible to break Columns AA1 to AD2 by a central loading,

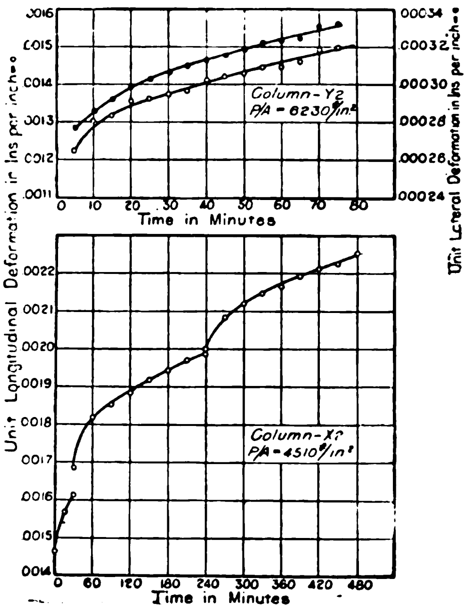


Fig. 4. Time Deformation Curves.

the rig shown in *Fig.* 1 was employed to test them under loadings eccentrically applied. Data on the strength of the columns thus tested are given in Table IV. In selecting the values given for the yield point, the determining factors were the stresses at which the stress-deformation curves showed a perceptible change of curvature, the yield point of the longitudinal steel, and the appearance of cracks along the spacing straps on the spiral. Under eccentric loadings, the values of P/A at the yield point were determined from evidence furnished by most stressed fibres of concrete and longitudinal steel.

The yield point of spirally reinforced concrete columns becomes more indistinct and less well-defined as the stiffness and strength of the concrete employed increases. This is due both to the decrease in the rate of curvature of the stress-deformation curve of the concrete and the decrease in the value of n. It is evident from Table V. that the compressive strength of this rich concrete was not developed at the same time as the yield point of the longitudinal mild steel. Consequently, the yield point of such columns as these is chiefly dependent upon the latter when mild steel is used.

From Division 3 of Table V. a comparison or estimation of the stiffness of Columns AA1 to AD2 may be made. The values of n tabulated in Division 4 of this table show that a large amount of longitudinal steel is not advantageous — theoretically, at least—in columns made of such rich concrete or mortar. Poisson's ratio or the factor of lateral expansion, μ, is considerably higher for this grade of mortar than for the 1 : 2 : 4 concrete tested at the laboratory last year. However, the proportionate amount of additional strength furnished by the spiral in these strong mortar columns is not materially increased, because a decrease in the value of n counteracts the effect of the increase in μ.

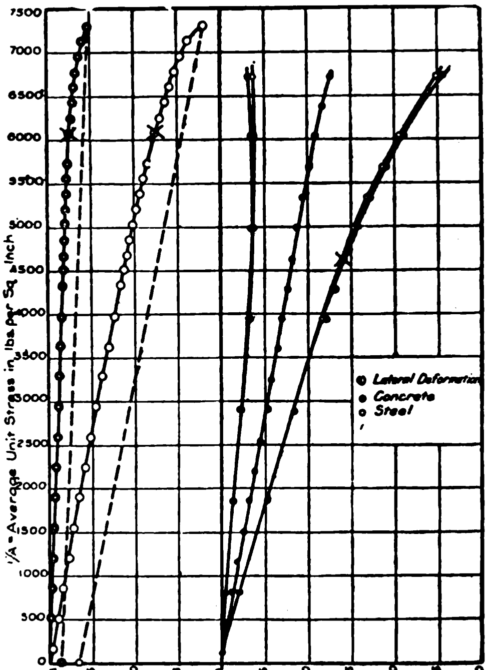


Fig. 5. Stress Deformation Curve, Column AA2.

Fig. 5 shows the curves between P/A and the unit-deformations for both central and eccentric loadings for column AA2. The crosses on the curves correspond with the stresses at the yield point. This column contained the strongest mortar of any tested, and its P/A-deformation curves show how remarkably stiff these columns were. Passing from left to right, the five sets of curves drawn for eccentric loadings represent the P/A-deformation curves for (1) the fibre of concrete furthest from the load, (2) the centre fibre of the steel rod furthest from the load, (3) the fibres at the axis of the column, (4) the centre fibre of the steel rod nearest the load, and (5) the outer fibre of concrete nearest the load.

Fig. 6 contains the P/A-deformation curves for Column AD2, in testing which four different eccentricities were tried. Similar curves were obtained from tests made on Column AD1.

TABLE IV.—DATA ON STRENGTH OF COLUMNS SUBJECTED TO ECCENTRIC LOADINGS.

Loads are arranged in the order of their application.

Col. No.	Long. Reinforcement, per cent.	Maximum Applied Load, lbs.	Maximum Value of P/A, lbs. per sq. in.	Load at Yield Point, lbs.	P/A at Yield Point, lbs. per sq. in.	Comp. Strength of Cylinders, lbs. per sq. in.	Eccentricity of Load, ins.
1	2	3	4	5	6	7	8
AA1	1·9	617,500	7,300	464,000	5,390	6,135	0
		540,000	*6,390	333,000	3,940	—	1·0
AA2	1·9	617,500	7,300	514,000	6,080	7,440	0
		601,000	*7,110	384,000	4,640	—	1·0
AB1	3·6	617,500	7,480	514,000	6,230	6,340	0
		540,000	*6,545	335,000	4,060	—	1·0
AB2	3·5	617,500	7,300	514,000	6,080	6,435	0
		594,000	*7,020	392,000	4,640	—	1·0
AC1	5·8	617,500	7,480	542,000	6,590	6,075	0
		627,000	7,600	421,000	5,100	—	0·5
		590,000	*7,150	—	—	—	1·0
AC2	5·6	617,500	7,140	515,000	5,940	5,835	0
		595,000	*6,890	351,000	4,060	—	1·0
AD1	5·7	157,000	1,850	—	—	6,795	0
		157,000	1,850	—	—	—	0·5
		157,000	1,850	—	—	—	1·0
		157,000	1,850	—	—	—	1·5
		420,000	*4,965	244,000	2,890	—	2·0
AD2	5·6	275,000	3,180	—	—	6,670	0
		275,000	3,180	—	—	—	0·5
		275,000	3,180	—	—	—	1·0
		275,000	3,180	—	—	—	1·5
		275,000	3,180	246,000	2,840	—	2·0
		481,000	*5,560	275,000	3,180	—	1·5

* Failed.

These eccentric loading tests afford an opportunity to compare theoretical stresses obtained by a modification of the formula

$$S=\frac{P}{A}\pm\frac{Mc}{I}$$

with the stresses calculated from deformations. In using the above formula proper allowance must be made for the steel in computing A and I. As used, it becomes

$$f_c=\frac{P}{A\,[1-P(1-n)]}\pm\frac{Pec}{PA(n-1)\frac{r_s^2}{2}+\frac{Ar^2}{4}}$$

In this formula f_c=stress in concrete fibre considered; P=load; A=total area inside of spiral; p=longitudinal steel ratio; n=ratio of modulus of elasticity of steel to that of concrete ; e=eccentricity of load ; Pc—distance from the axis of the column to the fibre considered, measured along the line of the eccentricity ; P_s=radius of the centres of longitudinal steel bars ; and r=radius of spiral. The stresses in the steel were computed by using the proper value of c and multiplying f_c by n. The formula assumes that the longitudinal steel is in the form of a thin pipe and makes no allowance for bending. However, the errors thus introduced are small for these columns.

TABLE V.—STRESS AT YIELD POINT AND ELASTIC PROPERTIES OF COLUMNS AA1 TO AD2.

Col. No.	Long. Reinforcement, per cent.	At P/A = 2,000 lbs. per sq. in. Values of			Comp. Strength of Cylinders, lbs. per sq. in.	Stresses at Yield Point, lbs. per sq. in.		Eccentricity of Load, ins.
		E, lbs. per sq. in.	$n=\frac{Es}{Ec}$.	μ		Long Steel.	Concrete.	
1	2	3	4	5	6	*7	8	9
AA1	1·9	5,800,000	5·6	0·20	6,135	32,000 42,000	4,890 —	0 1·0
AA2	1·9	5,800,000	5·6	0·18	7,440	37,500 42,000	5,480 —	0 1·0
AB1	3·6	6,200,000	5·7	0·21	6,340	35,400 37,500	5,150 —	0 1·0
AB2	3·5	5,800,000	6·1	0·16	6,435	35,100 40,200	5,030 —	0 1·0
AC1	5·8	6,100,000	6·4	0·16	6,075	36,000 35,600 40,200	4,760 — —	0 0·5 1·0
AC2	5·6	6,200,000	6·4	0·19	5,835	32,200 34,200	4,400 —	0 1·0
AD1	5·7	5,700,000	7·1	0·14	6,795	— 33,300	— —	0 2·0
AD2	5·6	5,200,000	8·0	0·13	6,670	— 34,800 34,800	— — —	0 2·0 1·5

* Values in Division 7 are computed from the deformation in the centre fibre of the most stressed steel bar.

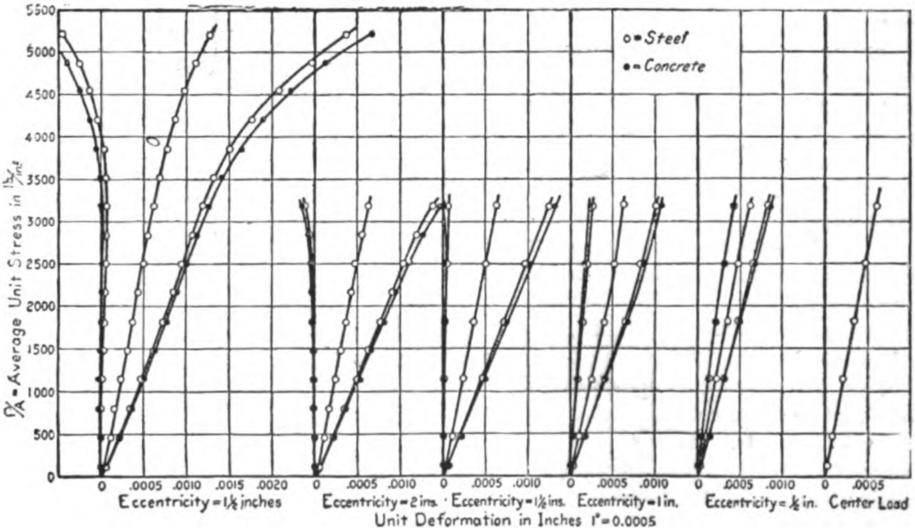


FIG. 6. STRESS DEFORMATION CURVES FOR COLUMN AD2, ECCENTRIC LOADING.

Fig. 7 shows the theoretical curves and the plotted points calculated from deformations for Columns AD1 and AD2, when the eccentricities were 2 in. and 1½ in, respectively. The single-primed letters refer to stresses on the outer fibre of concrete or the centre fibre of the steel rod nearest the load, and the double-primed letters refer to stresses on the corresponding fibres farthest from the load. In computing the values obtained from deformations, the same value of *n* was used as in obtaining the theoretical line. This value of *n* in all cases was computed from the stress-deformation curve from a central loading of the column considered.

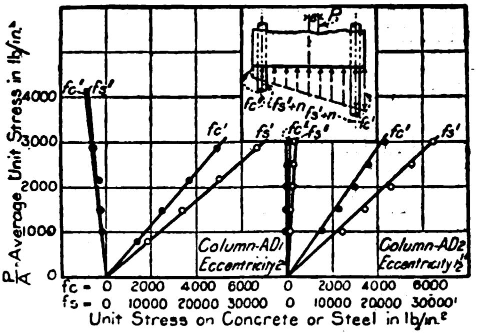


FIG. 7. COMPARISON OF THEORETICAL AND ACTUAL STRESSES, ECCENTRIC LOADING.

The above formula may be written $f_c=\frac{P}{A}(K\pm em)$ in which K and m are constants. Using the plus sign, and average values for K and m, it becomes for these columns

$$f_c=\frac{P}{A}(0{\cdot}74+0{\cdot}49e)$$

or

$$\frac{P}{A}=\frac{f_c}{0{\cdot}74+0{\cdot}49e}$$

which is the equation of an hyperbola when P/A and e are variables.

In *Fig.* 8 the quantities P/A have been calculated with constant values of f_c on the most stressed concrete fibre and for different eccentricities. The two lower curves are theoretical curves derived from the last equation, while the points represent values derived from deformations. The curves refer to values obtained from Columns AC and AD. The lower curve is for Columns AD1 and AD2 only. The upper curve has been drawn through the plotted values of P/A at the ultimate load, and, as will be noted, is quite similar to the theoretical curves drawn.

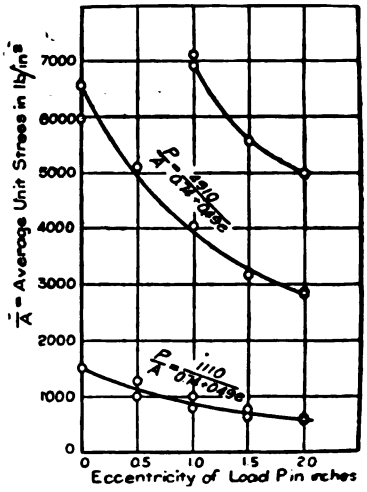


FIG. 8. AVERAGE STRESS, ECCENTRICITY CURVES.

Some of the conclusions which appear to follow from these tests are noted in the succeeding paragraphs.

1. The remarkably great strength and stiffness of many of the columns forcibly emphasizes the advantages of rich mixtures. In such columns, when centrally loaded, large percentages of either longitudinal or spiral reinforcement do not seem necessary, on account of the small value of *n* and the high cost of steel compared with the cost of cement. Longitudinal steel in larger amounts is of more advantage, however, in eccentrically loaded columns, especially in cases where tension may exist on one side of the column.

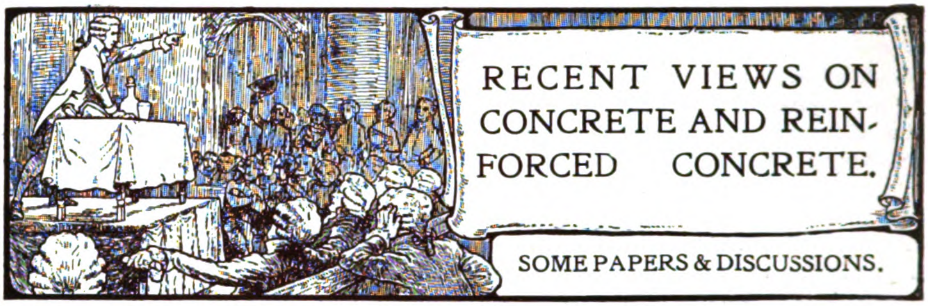
2. The amount of data presented on repeated or time loadings is far too little to warrant drawing definite conclusions as to the limiting stress for repeated loadings, which will hold true for all kinds of columns and for an infinite number of repetitions, or for a prolonged loading. However, it does appear from the tables and figures that there was practically no increase in set or deformation after a few repetitions of loads equal to 40 to 50 per cent. of the yield points of the columns tested.

3. The results also plainly indicate that there is considerable additional strength and toughness afforded by the spiral after the yield point of the longitudinal steel has been passed. That all of this additional strength may not be permanent is also suggested by the slope of the deformation-time curves for Columns X2 and Y2.

4. The close agreement between theoretical values and values derived from test data shows that the formula

$$S=\frac{P}{A}\pm\frac{Mc}{I},$$

commonly used in designing short homogeneous columns eccentrically loaded may be applied to reinforced concrete columns, provided suitable allowance be made for the steel.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

INSTITUTE OF BUILDERS.

AMERICAN METHODS AS APPLIED TO REINFORCED CONCRETE CONTRACTING.

Paper by MORITZ KAHN.

On October 5th, Mr. Moritz Kahn read a paper before the Institute of Builders on "American Methods as applied to Concrete Contracting," of which the following is an extract.

Comparative Unit Costs.—The unit costs of American constructions are generally lower than unit costs here, notwithstanding the higher rate of wages paid and the greater cost of materials in America. It may be granted that buildings here, in many instances, are of a more substantial character, but the difference in cost is not so much due to that consideration as to the saving of waste labour and materials by superior organisation. Competition in the States is as keen as in this country, and probably more so, for contractors spring up so rapidly there. The reason of their success under such keen conditions is invariably a question of fine organisation and rigid supervision. The idea that the American contractor is only anxious to fulfil his contract in the shortest time with the greatest amount of profit, paying no attention to the quality given the owner, is quite a mistake; for, like the English contractor, he is jealous of his reputation for doing good work; and if at times quality is sacrificed for the sake of speed in construction, it is due to conditions which are forced upon him.

The Plant Employed.—The investigation of contracting methods begins with the question of the plant employed. The reputation of a contractor may be fairly gauged by the completeness of his mechanical equipment. It is his object to reduce manual labour to the utmost limit. Mechanical mixers are used wherever possible; and even in constructions which involve as little as £1,000 worth of work, at least one concrete mixer is installed, sometimes several. The handling and mixing of concrete governs the cost to a great extent, and the use of a batch mixer is always advisable. When the concrete is mixed by hand it is turned from six to eight times, but in a mechanical mixer it is turned at least twenty times in a much shorter period, and with a considerable saving of expense. The plant, whenever possible, is laid out so that the raw material can be dumped into storage bins, the aggregate into one, and the sand into another. From the storage bins each is spouted into a measuring hopper, whence it is again spouted into the mixer. Such an arrangement eliminates considerable manual labour. The concrete is mixed very wet; this not only gives a better finished surface and a denser and stronger concrete than a dry mixture, but it is also more economical in the placing, as it will pack itself.

Testing the Cement.—All cement used in the construction is tested on arrival. An up-to-date contractor will have his own apparatus, making his tests for his own satisfaction, apart from the requirements of the specification. He pays for a certain quality, and by repeated testing determines for himself whether he is getting his money's worth; besides which, frequent testing saves the contractor any future trouble arising from the use of poor materials.

Depositing and Hoisting the Concrete.—When deposited in mass, as for foundations, trenches, walls, etc., the concrete is trucked to the points where required; when it is used in small batches hand barrows are employed. The American barrow is quite different from the English barrow, the latter being generally made of wood in a substantial, heavy manner, with a capacity of from 1 to 1½ cu. ft. of concrete. The American barrow, on the other hand, is wholly or partly constructed of iron, in the latter case in the form of a metal tray on a wooden frame, which saves weight, and the construction is such that the load is well balanced on the wheel, with the result that a greater quantity of concrete can be handled with no extra exertion on the part of the workmen. Ordinarily, this barrow has a capacity of 4 cu. ft.

The means of hoisting concrete is carefully studied. Elevators or cages in duplicates are frequently used, one hoisting a loaded barrow, the other lowering an empty one. The advantage of the double over the single elevator type lies in the fact that the workman who brings the full barrow immediately returns with the empty one, whereas in the single elevator type he must wait until the elevator has made a complete round trip for this same operation. Preference, however, is generally given to the method of hoisting concrete by means of self-dumping buckets. The entire batch of concrete is spouted from the mixer directly into the bucket, which is hoisted up a tower and automatically dumped at the proper level into a hopper, from which the material is fed into hand barrows and delivered to its final position.

Erection of Centering.—The erection of the centering is carefully studied in large works. The design of its construction is schemed out at the head office before the work is commenced, so as to give the greatest economy. The forms are generally built in panels to enable their being repeatedly used on different portions of the work. They are erected so that the supports of the decking slabs, together with the beam sides, can be removed first, leaving the beam bottoms with their props in position for a longer period. In centering for the columns, the four sides are built up complete, and the concrete is poured in from the top, instead of the three-sided centering so commonly seen in England, where the concrete is poured in from the side of the column, the fourth side being boarded up as the concrete work proceeds. A hand hole is left open at the foot of the column so that all wood blocks, shavings, etc., which may have fallen into the form can be removed before the concreting is begun. Pouring concrete into columns from the top is more economical than placing it from the side. In column centering, bolts or clamps are used to a considerable extent. For walls, the centering is also built in panels, which are held together by bolts and kept the correct distance apart by means of braces. This arrangement enables the centering for walls to be struck in three or four days' time for use in succeeding portions of the work. The bolts are removed from the concrete, and the holes so left are patched up with cement mortar. The actual work of placing the concrete is not commenced until a considerable area of centering has been constructed, as the laying of the former involves much less time than the erection of the latter, and, with a large portion of centering completed, opportunity is given for working the concrete plant to its fullest capacity, which gives the best and most economical results.

Scaffolding.—The American scaffolding is entirely different from the English. Low buildings are sometimes scaffolded from the ground, but in the higher buildings, which are the rule, the scaffolding is raised from floor to floor. When it is necessary to lay brick or stone work from the outside, the scaffolding is cantilevered from the windows at the various storey heights. It should be noted that high buildings are always built on the skeleton type, the supporting columns and all the floors being erected first. The walls, which are built afterwards, generally consist of thin panels from 9 in. to 13 in. thick, supported by the external columns and beams. Apart from the economy arising from the decreased thickness of the wall, the advantage of this form of construction lies in the fact that after the skeleton is erected the contractor can carry on his mason work at two or three different levels, which is convenient when the time of erection is limited. For scaffolding internal walls the Gilbreth method is probably the best. The scaffolding itself consists of three platforms, the one used by the men with their barrows supplying the materials to the masons ; the second carries the materials required ; the third is for the use of bricklayers. These three platforms are carried on a high trestle. As the brick wall goes up the labourers raise the three platforms up the trestle by means of a lever, which is operated by the men on the scaffolding. By the use of this scaffolding the labourers with their barrows all move in the same direction, going up the scaffolding platform at one end of the building, walking along to feed the masons at the different points, and coming down at the other end, and there is no confusion due to men moving in opposite directions. With this method of scaffolding all the internal walls of a good-sized building can be constructed in a single day.

The Reinforcing Steel.—This is handled in large quantities, both in unloading it from the carts and in hoisting it to the different levels. For this purpose it is generally bundled into one-ton lots, mechanical appliances unloading it from the carts and hoisting it to position. In the selection of the system of reinforcement used the contractor has a choice of many kinds, and he adopts that system which, in his opinion, involves the least amount of manual labour at the site of the construction. Any difference in the cost of the various forms of reinforcement is always considered in conjunction with the amount of labour involved in fabricating and placing it in position.

Recording Progress.— A simple and effective method enabling the principal at the head office to ascertain the state of progress at any time is the use of what are called " diagram sketches." When a contract is started the resident engineer is supplied with a quantity of small, single-line diagrams showing sections and plans of the building. As the work progresses he sends to the head office, with his weekly report, one of these diagrams tinted in various colours to show the amount of work done during the preceding week.

Estimating Cost.—The American method of estimating the cost of construction for tendering purposes is open to considerable criticism. Instead of a quantity surveyor being employed, as is the case in England, each contractor has his own estimating clerk, who prepares the quantities from small scale drawings supplied, together with specifications describing the work. Very often on account of the meagreness of the information given and the short time allowed the preparation of the quantities is based on judgment instead of measurement, and under such conditions contracting becomes more or less of a gamble. While the lack of scheduled quantities has disadvantages, it has the advantage that extras and changes very seldom occur. Without a schedule of prices the owner or architect is loth to make any changes, the pricing of which might prove bones of contention. Therefore, when a contractor has once planned his method for carrying out the work, he proceeds with the execution of it with little interference from the owner or architect, and it is carried out exactly as shown on the signed contract drawings.

Checking Costs of Labour and Materials.—Careful records are kept to show the total cost of all labour and materials used up to Thursday of each week. Thus the principal of a firm can definitely determine on any Saturday morning the cost of the construction up to and including the preceding Thursday. He does not wait until the job is finished to determine whether he has made or lost money, but ascertains this weekly by comparing the total cost sheet with the original estimating sheet. From this weekly examination any leakages are traced before a large loss results. The daily time-sheets are so arranged that the cost clerk can find out accurately therefrom the unit price of any labour performed. All unit costs are recorded and become valuable information for future tendering purposes. The system of recording costs must necessarily be complete, as contractors work over a large territory, and execute structures of various types. One building is erected in one State, another perhaps a thousand miles distant ; one may be a factory and the other a city skyscraper.

Systematic Estimating.—Reference has been made to the gambling tendency which results in hurriedly estimating and tendering on a lump-sum basis. To eliminate this two systems of contracts are now being extensively used—viz., the cost *plus* a percentage, and the cost *plus* a fixed sum or premium contract. Under the latter system the contractor becomes a professional man, who, like any other expert, is employed to administer and conduct the enterprise in its executive department, being paid a fixed fee for his services. When an owner adopts this system he selects his contractor at the same time that he appoints his architect. The architect secures the advantage of the contractor's practical experience from the very start. The specifications are prepared, not only from a technical, but from a practical point of view. All questions regarding the supply of labour and material, seasons and weather, and the physical difficulties which are apt to present themselves, are thoroughly discussed, and the entire proposition is then laid before the owner in a comprehensive manner at the outset. He has the benefit of two trained minds, the one scientific and the other executive ; the one furnishes his knowledge of design, the other his practical knowledge of what the man in overalls can do. Under the form of contracts here discussed the owner defrays the cost of all materials, and by paying cash can take advantage of any special discounts, making a considerable saving. Again, alterations in the ordinary contract are always causes of annoyance, and under this system that annoyance is removed, as the owner pays merely the cost of any changes he may wish to have carried out. The contractor having been selected, he can commence excavating immediately, and proceed with the work as the drawings are supplied by the architect, saving the time which is ordinarily lost in waiting for the drawings to be entirely prepared before starting. The owner at all times has full control over the number of men employed, and thus regulates the speed of the construction. When a lump-sum contract is entered into the contractor employed is generally the one who submitted the lowest tender, and sometimes an irresponsible firm is selected. Under the new system, however, the owner makes his choice from a representative list of contractors, finding it possible to employ the best firm at no extra cost. The object of this form of contract is to give the owner an economical construction, carried out in the best manner and in the shortest space of time, with the further object of seeing that the contractor has a fair profit for his services. The merits of the system of contracting herein outlined are too numerous to discuss at length, but it would be well worth while for the English contractor to make some concerted movement in the same direction.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.

THE USE OF CEMENT IN ARCHITECTURE.

By F. G. BAKER, Toronto.

President Royal Architectural Institute of Canada.

At the Second Annual Convention of the Canadian Cement and Concrete Association, Mr. F. G. Baker, President of the Royal Architectural Institute of Canada, delivered a lecture on "The Use of Cement in Architecture," of which we give a summary.

Setting of Concrete.—The subject of concrete will be well covered by various speakers at this meeting, but there is one feature which occurs to me, I refer to the injury which concrete in course of setting receives from any sudden jar. To obviate this where concrete is used for floors in steel frame buildings, I think the architect should provide additional steel sufficient to insure a stiffness in the frames which would prevent injury to the concrete by the vibration incidental to the erection of any steel frame building. I have observed that concrete placed in moderate freezing weather, say, twenty degrees and above, which is allowed to set fully without any vibration, seems to be as good as that set in non-freezing weather.

Waterproofing.—Portland cement has proved very useful in forming surfaces to resist water or tanks to contain fluid, such as cisterns, swimming baths, egg tanks, etc., but the success of this depends largely on the mixture. In a case like egg tanks it is exceedingly important that the walls should be absolutely tight, as the slightest subsidence of the fluid caused the eggs at the bottom of the tank to be crushed.

Floors.— Concrete seems to be the ideal thing for floors which lie upon the earth, such as basement floors, or verandah floors, or sidewalks. As a finished floor for a building, however, I do not think a cement and sand or marble dust composition is satisfactory, and the same applies to staircases. I refer, of course, to places where there is heavy traffic, as the floors or treads at once begin to wear, and the consequent deposit is carried into adjoining rooms.

Cement Mortar.—Portland cement shows its greatest usefulness to the architect in the mortar which is now almost universally used in the laying up of brick walls. I mean cement mortar, one to three. A brick wall laid in such mortar and grouted with liquid cement grout a very few courses becomes as hard as solid stone, and the builder has the assurance of strength, from his knowledge of the soundness of the bricks and of their resistance to crushing. I have watched men cutting an opening through such a brick wall, and the hard bricks generally yield before the mortar. Such masonry is a great comfort to the architect, and while I say this I am a great admirer of the wonderful feats which have been performed in the erection of immense reinforced concrete structures, and I am satisfied that it is a practical building process. The use of cement mortar in the building of rubble stone walls is also a great boon to the architect; no rubble stone work should be attempted in anything but cement mortar, where cement is obtainable. The failure which I have seen in rubble stone work would in every case have been avoided if cement mortar had been used.

Artificial Stone.—Of the several kinds of artificial stone I prefer that which is formed of the same material all through and not formed in the main of one kind of concrete and faced with another. There is apt to be a difference in the expansion and contraction of two materials and a difference in the retention of moisture, which might reduce the strength of the latter article, as compared with that which is formed of the same material all through. It is clear, however, that an architect must be drawn into the reproduction of a feature so easily obtained in artificial stone in an effort to economise. On the whole, I like artificial stone very much and wish it every success.

Embellishments.—The use of cement has also made possible many embellishments for the exterior of the building which could otherwise only be obtained at great expense. A whole wall surface may now be safely covered with cement plaster, either on masonry work or metal lath, and the craftsman feel assured that it will stay in position, while at the same time it may be enriched with ornaments by the skilful carver. On the other hand, friezes protected by roofs or other protections can be modelled in relief on the building quite as successfully as a frieze carved in stone, and at much less expense.

THE CONCRETE INSTITUTE.

THE MANUFACTURE OF PORTLAND CEMENT.

Paper by A. C. DAVIS, F.C.S., Assoc.Inst.C.E.

The Twelfth Ordinary General Meeting of the Concrete Institute was held on Thursday, October 27th, 1910, at 8 p.m., at the Royal United Service Institution, Whitehall, London, S.W., on which occasion Mr. A. C. Davis read a paper entitled "The Manufacture of Portland Cement," of which we give an extract.

ORIGINALLY invented in England some three-quarters of a century ago, the British makers of Portland cement adhered solidly to old-fashioned methods for some decades, but which have now at last had their day, and it has been only within the past ten years that the British cement maker has awakened to the seriousness of foreign and home competition.

For some years we have been actively engaged in building modern cement works and putting down up-to-date plant in our obsolete factories, with the result that for quality of product, combined with low cost of production, the British manufacturer has nothing to fear from oversea competitors, and British Portland cement to-day has no rival in quality the world over.

It is safe to assume that one of the Thames tunnels, constructed in 1828, was the first engineering work of importance in which Portland cement was used—the price at that time was, by the way, 21s. per cask at the works, and to-day a much superior quality product can be purchased at some 4s. per cask, so much have the conditions of the industry altered in the past three-quarters of a century.

What Portland Cement Is.—Now, what is Portland cement? The term "Portland" is limited to a hydraulic cement containing a large percentage of lime, and at once distinguishes the valuable constructive material bearing that title from other cementitious substances.

The British Standard Specification defines Portland cement in the following terms:—"The cement shall be prepared by intimately mixing together calcareous and argillaceous materials, burning them at a clinkering temperature, and grinding the resulting clinkers."

Centres of Manufacture.—The centres of the manufacture of Portland cement are well distributed over the country. The normal size of a factory is one having an output of some 500 to 1,000 tons per week, and in this country alone we have some eighty cement companies, with a total output of some 3,000,000 tons of cement per annum.

Necessary Constituents.—Portland cement can be produced from any raw materials containing constituents capable of yielding by calcination the silicates and aluminates of lime which form its chief components, and the necessary constituents of these raw materials are lime, silica, and alumina. Small additions of iron oxide are desirable for fluxing these materials.

In manufacturing Portland cement, carbonate of lime and clay are first efficiently and accurately amalgamated in fixed proportions, either by the addition of water to the raw materials or by fine grinding and mixing in their dry state.

The composition of a prepared mixture of these raw materials should be roughly three parts of chalk to one of clay. Now the various raw materials employed in the manufacture of Portland cement at the present day may be described as follows:

Materials in Various English Districts.—In the Thames and Medway districts the chalk formation on the banks of these rivers is quarried, and this material is mixed with the deposits of mud found in the estuaries and creeks.

The chalk marls around Cambridge have been well proved to be eminently suitable for the manufacture of a first-class quality cement. The "marl" is a deposit of calcareous and argillaceous material found at the base of the local chalk. The chalk marl of Cambridgeshire, though the relative quantities of chalk may vary from yard to yard in depth when testing on the face of the quarry, contains in the aggregate about the same proportion of calcareous and clayey material as is obtained artificially by the mixture of chalk with alluvial mud in the Medway Valley.

In the cement-making districts of Rugby and South Wales we have the well-known lias formation of limestone and shale, and this is successfully treated for the manufacture of Portland cement. The thin layers of these materials, with their variation in composition, must similarly be very accurately and efficiently dealt with. In working the lias formation it is found that the preponderance of shale in proportion to limestone (which is generally found to contain 78 to 85 per cent. of carbonate of lime) renders the cost of working heavy, because of the removal of surplus clayey material not required in the manufacture.

On the Tyne, Wear, and Tees, and in the North of England generally, Portland cement is manufactured from chalk imported from the Thames, Medway, or Sussex districts, and this is mixed with a local clay found on the site of the works. From this mixture a good quality cement is manufactured.

Materials in U.S.A. and Germany.—In the United States most of the cement produced is from the Lehigh Valley argillaceous limestone, which contains rather more clay than is required for a correct mixture. To this a small amount of pure limestone, usually 10 to 20 per cent., is added to bring the mixture up to the necessary percentage of calcium carbonate required in the manufacture.

In Germany the raw material consists of chalk marl.

Three Primary Processes.—The primary conditions of any method of Portland cement manufacture are that the raw materials shall be: (1) Correctly proportioned; (2) very finely comminuted; and (3) thoroughly mixed.

The proportions of chalk and clay must be kept to a standard as closely as ever possible, which work at the present time in the most successful cement works is carried out under the supervision of the works chemists. The reduction of the raw material depends chiefly upon their character, so that the details of the methods adopted by manufacturers for grinding generally vary with the raw materials used. There are two principal methods of reducing and mixing the raw materials—namely: Firstly, by the "Wet Process" applicable only to soft materials, the correct quantities of the raw ingredients being ground and mixed by the aid of a considerable amount of water. Secondly, the "Dry Process," in which the perfectly dry materials are ground together to an impalpable powder or "flour," and subsequently mixed to correct chemical proportions.

Burning or Calcining.—The next stage in the manufacture of Portland cement following the scientific and mechanical preparation of the raw material is that of burning at a high temperature, or calcining, the raw product at a point of slight vitrifaction, resulting in what is commonly called a cement "clinker." The proper degree of burning is indicated by the formation of a dense greenish-black clinker when coming from the kilns. Light-burned clinker is brownish and soft, while over-burned clinker is fused and slag-like. The aggregate temperature in the process of calcination shows that for normal Portland cement burning a heat is required in the kiln amounting to 1,400° C., or 2,500° F. This temperature is variable, according to the percentage of carbonate of lime contained in the raw materials—namely, the higher the proportion of lime the higher the temperature which is necessary to produce complete diffusion in combination with silica.

Intermittent and Continuous Kilns.—The kilns for burning the raw materials are always constructed for either an "intermittent" or "continuous" process. The intermittent kilns require loading and drawing, and demand the shutting down of the kiln during the drawing operation. In the continuous kilns, the burning of the raw material proceeds without a break, and the drawing of the clinker takes place at the same time without interruption, thus making a continuous process.

In the category of continuous kilns we come to the process of burning by the rotary kiln which has been lately brought into use. The manufacture of cement by the rotary kiln may be said to have revolutionised the industry, and this method of burning the raw materials is, perhaps, the most scientific and practical invention that has been introduced into the manufacture since Portland cement was first known. The rotary kiln consists of a slightly inclined steel or wrought-iron cylinder, usually from 100 to 150 ft. in length, and 6 to 8 ft. in diameter, and is inclined to the horizontal at about 1 in 30. The kiln is lined with radial firebricks, some 9 in. in thickness, and the long cylinder is mounted on tyres running on rollers and slowly rotated by gearing.

The cement-making materials are continuously fed into the kiln through a pipe at the upper end in the form of either liquid mud or dry powder, according to the process adopted in preparing and mixing the raw materials. Finely-ground coal is almost always used as fuel, and this is introduced into the lower or outlet end of the kiln by a jet of air issuing from a blast fan.

The raw material, as it gradually descends into the zone of heat generated by the perfect combustion of the finely-ground coal fed into the cylinder from the opposite end, parts with any carbonic acid, forms little rounded balls which reach a nearly white heat in the lower third of the kiln, and finally issues at the lower end as well-burned clinker in grains about the size of a large pea. The greatest heat is naturally near the fuel-jet or outlet end of the kiln. The hot clinker from the kiln is cooled either by being elevated to cooling towers or by rotary cooling drums.

Clinker Grinding.—The true test of quality in a cement, to-day, is the fineness to which the cement is ground. In modern works the preliminary grinding of cement clinker is carried out by the ball mill, and from this mill the coarsely-ground material is conducted to a tube mill which finishes the fine grinding previous to storing the cement. The finished cement is ground sufficiently fine to pass through a 76 by 76 mesh sieve with about 1 per cent. residue, and although finer grinding is rarely demanded, it can be readily accomplished by the manufacturer if necessary.

Stores.—From the grinding mills the cement is conveyed into the stores, and after it has cooled down the material is ready for loading out at the factory. It is generally considered that the longer the cement is kept in stock the more reliable it is to be found in use; but the modern product of to-day's manufacture requires neither storage nor aeration to provide and ensure the success of its quality.

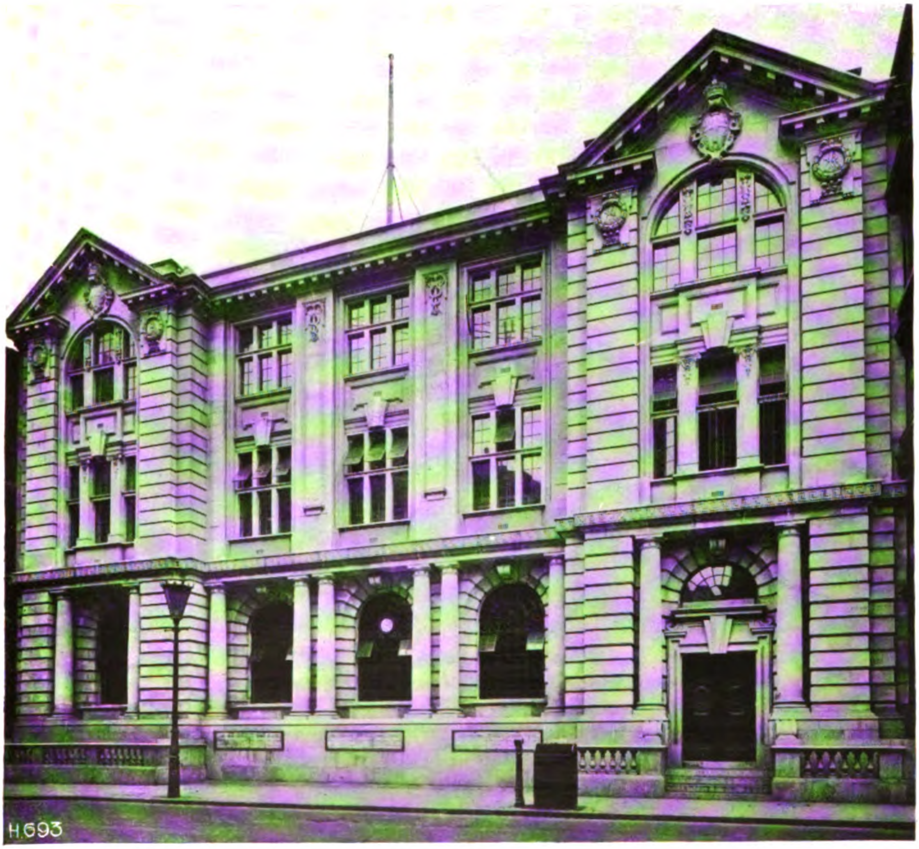
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

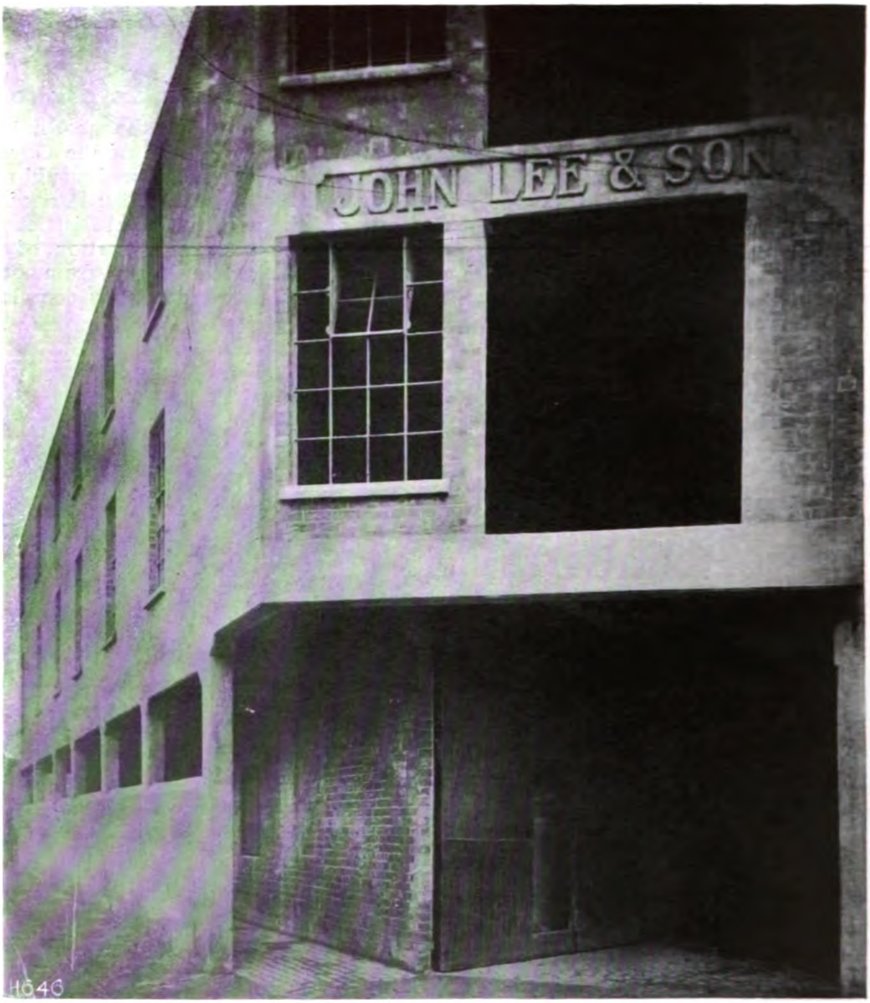
NEW GENERAL POST OFFICE BUILDINGS, ST. MARTIN LE GRAND.

THE new General Post Office buildings, which are now completed, is the most notable example of a reinforced concrete structure erected at the expense of the Government. We have dealt with this building on more than one occasion, and would refer in particular to our issue of January, 1909, for full structural details. Part of the new building is already occupied by the Controller of the London Postal District and his staff, and it is expected that the public office, which forms a portion of the structure, will be opened shortly. The view below and the frontispiece, from photographs specially taken for this Journal, show this important building as completed with well-designed stone façades.



Front to Newgate Street.
NEW GENERAL POST OFFICE BUILDINGS, ST. MARTIN LE GRAND.

These buildings have been designed by Sir Henry Tanner, I.S.O., F.R.I.B.A., principal architect to H.M. Office of Works, and were executed on the Hennebique system of reinforced concrete, Messrs. Holloway Bros. being the contractors. The Portland cement used was the "Hilton Anderson" brand, manufactured by the Associated Portland Cement Manufacturers, while most of the steel rods were supplied by the Whitehead Iron & Steel Co.



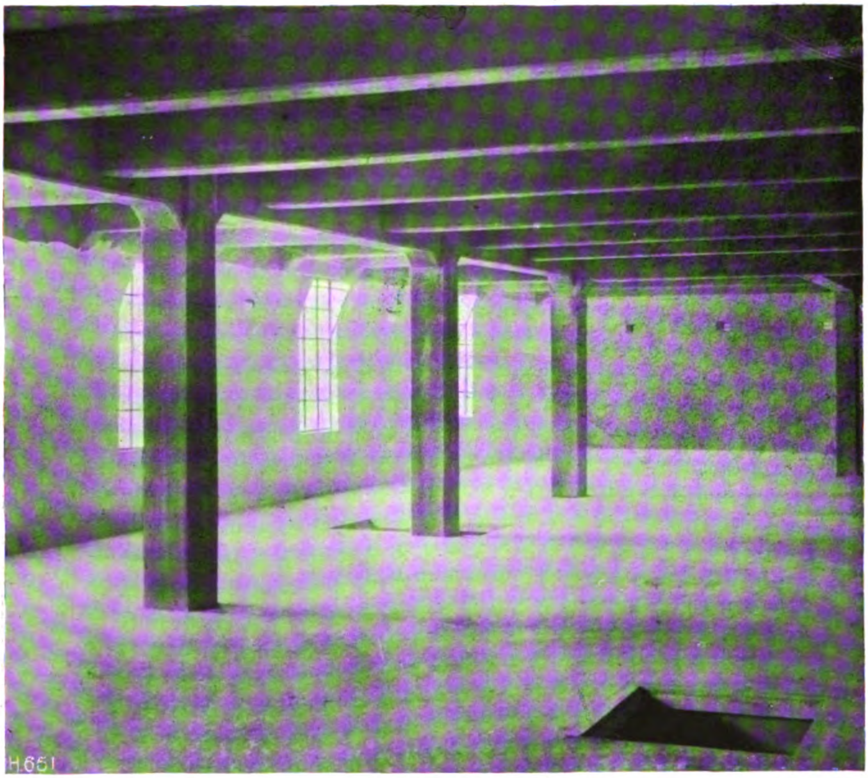
Elevation to Welby Street.
Reinforced Concrete Warehouse at Grantham.

REINFORCED CONCRETE WAREHOUSE AT GRANTHAM.

In the old-world town of Grantham—where Sir Isaac Newton received his education at the Grammar School—there are lasting monuments of the mediæval builders' skill.

Notwithstanding the architectural effects of these old methods of construction, modern business demands for its accommodation and successful enterprise that the buildings erected for its use shall be constructed in a modern method for utility and endurance. Reinforced concrete was therefore introduced into Grantham in the erection of a new warehouse, in Welby Street, for Messrs. John Lee & Son, who carry on the business of furriers and general dealers.

On the first inception of the scheme for erecting the warehouse the proprietors contemplated building it on stereotyped methods of construction, with brick walls, wooden floors supported on steel girders, after the usual methods of combustible buildings. Plans were prepared and tenders obtained for erecting the building on this system, as well as in reinforced concrete, and it was found that the latter method of construction worked out considerably cheaper, and had so many advantages for a furrier's business, that it was decided to adopt it.



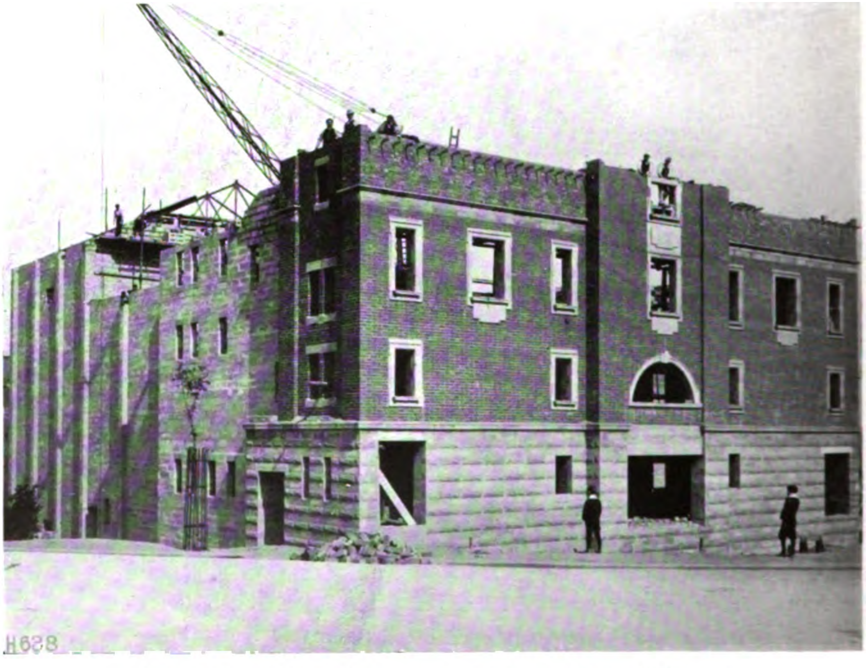
Interior, showing beams and stanchions
Reinforced Concrete Warehouse at Grantham.

The building consists of the ground floor and three upper floors, the upper portion being adapted for drying skins. The stanchions, beams, and floors are all constructed in reinforced concrete, and present a dignified and solid appearance, the interior being not unlike a structure built up with heavy timber beams. The panels of the exterior walls, formed by the reinforced concrete stanchions and beams, are filled in with 9 in. of red brickwork, the combination presenting a very pleasing and ornamental façade to the frontages. One special feature in the building is the way in which the upper portion is supported on cantilevers over the entrance gates, the front wall almost appearing as if unsupported, as shown in the illustration on page 842. In the interior of the building it was necessary to leave an area 4 ft. wide for light and air, and the difficulty of carrying the exterior wall of this area without having stanchions to obstruct the floor space on the ground floor was overcome by carrying the ends of the reinforced concrete beams on cantilevers,

The steel reinforcements throughout were supplied by the British Standardised Reinforcement Co., 39 Victoria Street, Westminster, S.W., each reinforcement being delivered upon the site framed together, so that all that was necessary to ensure the steel being in the exact position required in the beams and stanchions was to lift them into the wood casings and place the concrete around. This method of construction was found to expedite the building operations very considerably, and it ensured that no mistake could be made in placing the reinforcements, as they were firmly fixed together, and the stools supported the steel bars at the exact height necessary to obtain the maximum tensile strains being taken up by the reinforcements.

As showing the economy of this method of construction, the building was erected complete at the small cost of 3d. per cu. ft.

The engineers for the work were Messrs. Saunders & Saunders, 39 Victoria Street, Westminster, and Newark-on-Trent ; and the contractors, Messrs. D. Parks & Son, of Grantham who successfully carried out the undertaking in a workmanlike and substantial manner.



THEATRE ROYAL, BARRY DOCKS, BUILT MAINLY OF "WINGET" BLOCKS.

THEATRE ROYAL, BARRY DOCKS.

WE have dealt very often with the advantage of using concrete blocks for buildings, and have illustrated on different occasions villas, miners' cottages, and other smaller dwellings built of blocks, while in the present instance we show an illustration of their suitability for large buildings.

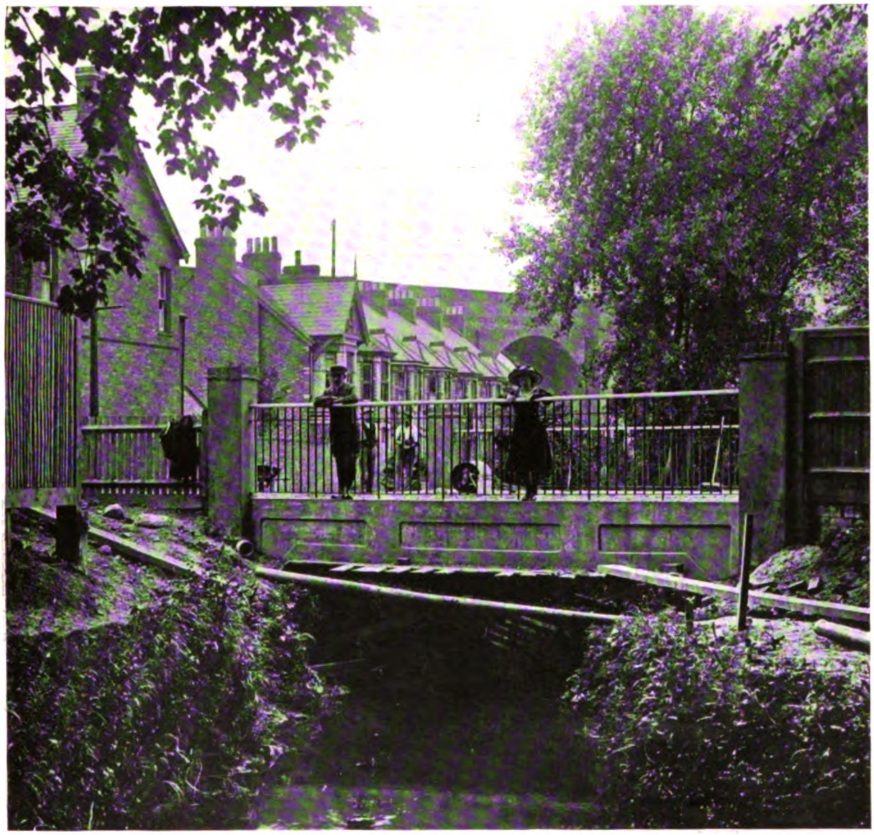
The reproduction on this page is of the Theatre Royal, Barry Docks, built chiefly of concrete blocks made on the "Winget" machine, manufactured by the U.K. Winget Concrete Machine Co., Ltd., of Newcastle-on-Tyne.

Fifteen thousand blocks are being used for the erection of this building, and two "Winget" machines are in use on this work. The theatre is being built for Mr. Arthur Carlton, and the contractors are Messrs. Nicholds & Reynolds, of King's Court, Broadway, S.W.

SOME REINFORCED CONCRETE BRIDGES.

REINFORCED CONCRETE BRIDGE AT EXMOUTH

THERE has lately been completed at Withycombe Road, Exmouth, a very economica reinforced concrete road bridge, which has a clear span of 18 ft., and a total width of 40 ft. on the square. The bridge is built on a slight skew, and carries an important roadway over a stream.



REINFORCED CONCRETE BRIDGE AT EXMOUTH.

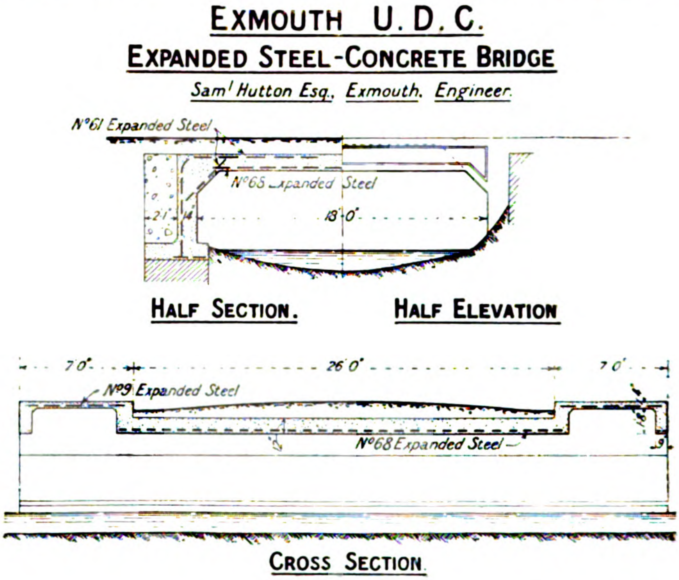
The superstructure consists of a simple slab spanning over the 18 ft. opening without beams, and is 12 in. in thickness under the road metal, the reinforcement being No. 68—3-in. mesh $\frac{1}{2}$ in. by $\frac{3}{16}$ in. bare strands—expanded steel.

The abutment walls are 14 in. in thickness, and were placed on the foundations of the old bridge, which were considered sufficient to carry the new structure, the reinforcement for the walls being No. 61—3-in. mesh $\frac{5}{16}$ in. by $\frac{1}{8}$ in. bare strands—expanded steel. Behind the reinforced concrete abutment walls was placed rough concrete to fill up the excavation.

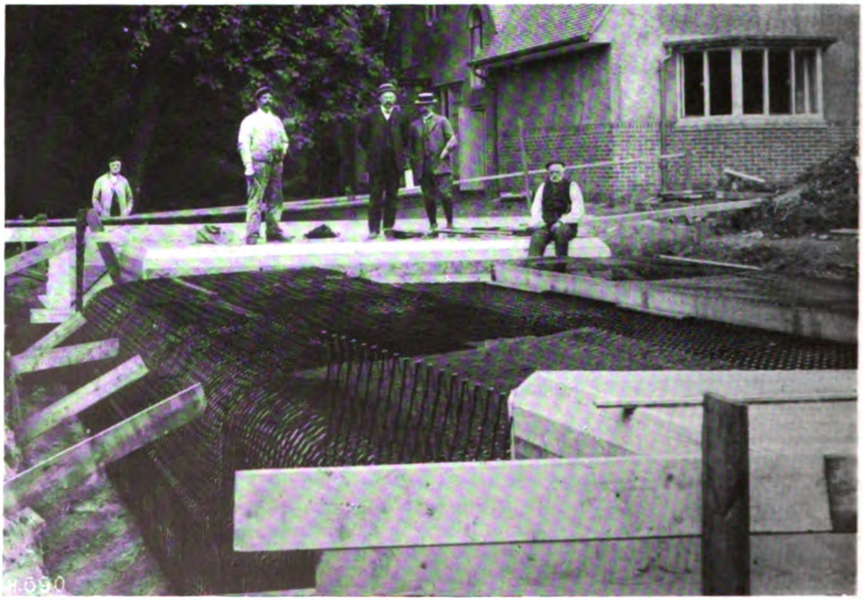
Details of the work are shown on page 846, also a view of the expanded steel reinforcement in position ready to receive the concrete. The illustration on this page shows the finished structure before the removal of the temporary timbering.

On completion the bridge was tested by means of a heavy road roller running over it, and the deflection under the load was imperceptible.

The work was carried out departmentally to the general designs, and under the supervision of Mr. Samuel Hutton, Borough Engineer of Exmouth; the details of the reinforced concrete work and the expanded steel reinforcement were supplied by the Expanded Metal Co., Ltd., of London and West Hartlepool.



Details of bridge.



Expanded steel reinforcement in position.
REINFORCED CONCRETE BRIDGE AT EXMOUTH.

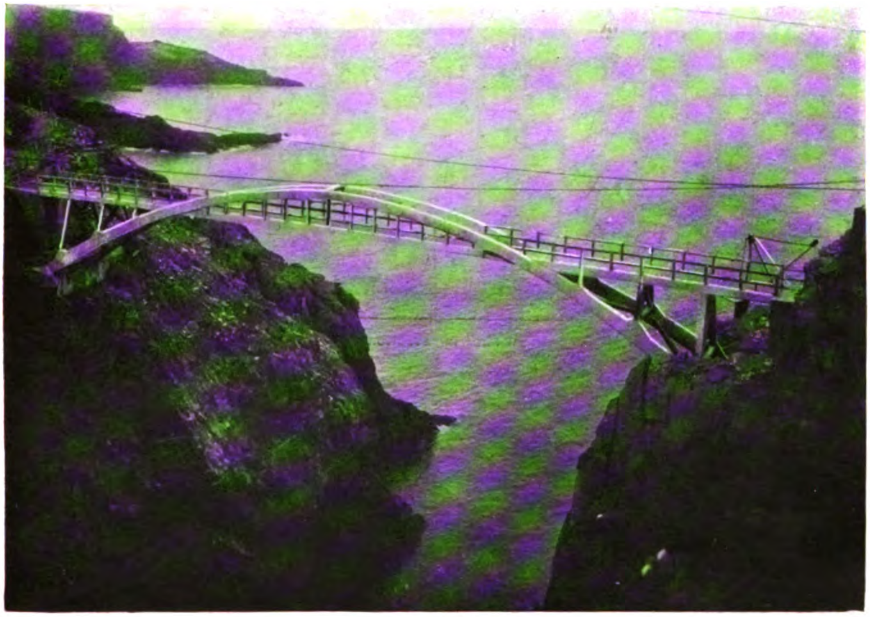
FOOTBRIDGE AT MIZEN HEAD, IRELAND.

THIS bridge was erected to provide access to Cloghan Island at Mizen Head, the extreme south-west point of Ireland, on which the Commissioners of Irish Lights have built a fog-signal station.

The island is separated from the mainland by an inlet of the sea, and the site chosen for the bridge necessitated a span of 172 ft. at a level of 150 ft. above the sea.

Designs were called for, and Mr. C. W. Scott, Engineer to the Commissioners, chose the design sent in by Mr. M. Noel Ridley, of Westminster, for a bridge in reinforced concrete under Ridley & Cammel Patents. A concrete bridge was preferred to a steel bridge, for which several cheaper designs were sent in, as the maintenance of the latter would be so costly and the life so short in such an exposed position where the bridge is often smothered in spray and wet fogs are prevalent.

The contract was placed in the hands of Messrs. Alfred Thorne & Sons, of Westminster.



View of finished bridge.

REINFORCED CONCRETE FOOTBRIDGE AT MIZEN HEAD, IRELAND.

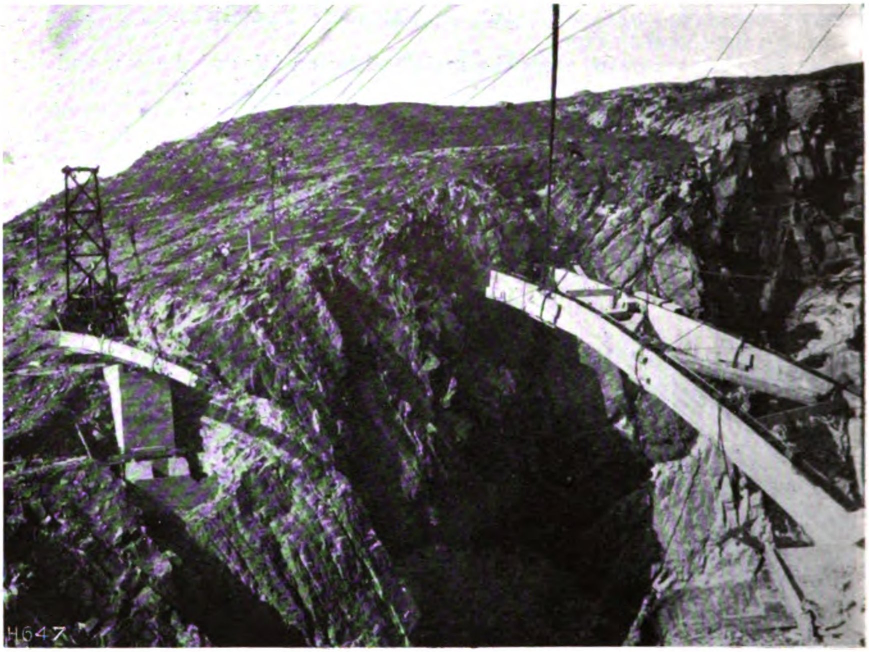
The bridge is 172 ft. long in one span and is of the through arch type, the ribs being parabolic curves with a versed sine of 30 ft., and are of rectangular section 3 ft. by 1 ft. at the springing, and 1 ft. 6 in. by 1 ft. at the crown. The ribs are parallel in the centre portion, 5 ft. 6 in. centres, but where the footway cuts through at the quarter spans they splay out, being 15 ft. centres at the abutments, and are connected by wind-bracing ; this is to give stability under wind pressure as the bridge is so narrow.

The footway is 4 ft. 6 in. wide between the horizontal beams, and is 5 in. thick at the centre, including the granolithic surface ; the beams are 15 in. by 9 in., and the reinforcement is made continuous from end to end by rigid connections, and is anchored to the rock on either side to stiffen the bridge under unequal loading.

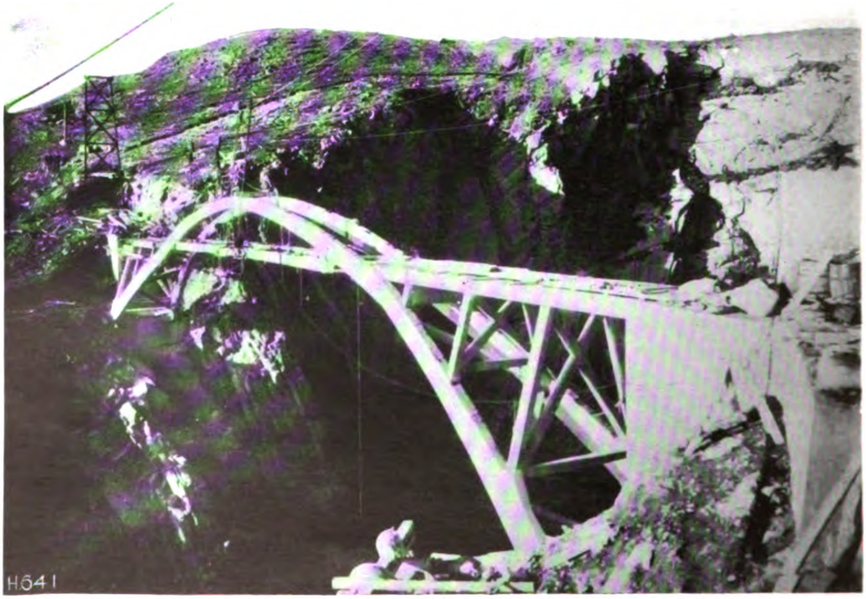
The trestles and wind-bracing are of 9 in. by 9 in. section, and the hangers 9 in. by 6 in.

The handrail is of reinforced concrete with 4-in. octagonal rails, and posts 9 in. by 6 in. to 6 in. by 6 in.

The rock on either side is benched out to receive the concrete abutments in which the ribs are bedded.



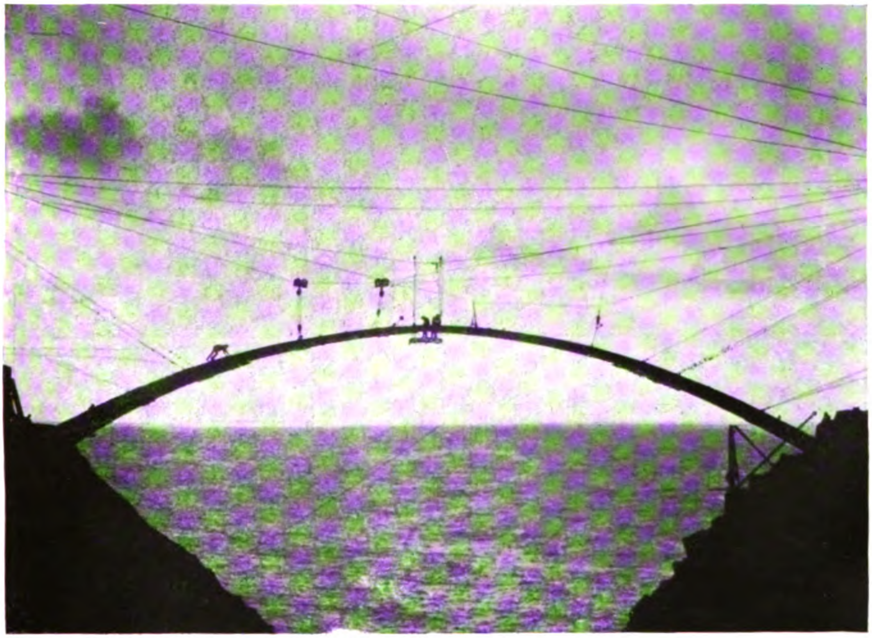
View showing erection of ribs.



View of bridge before floors were erected.
REINFORCED CONCRETE FOOTBRIDGE AT MIZEN HEAD, IRELAND.

The novel feature of this bridge, apart from its great span, which is believed to be the greatest yet attempted in the British Isles, and its height above water, is that it was possible to erect without centering, thus effecting a great saving in cost. The ribs were made in four portions, each on shore, and then built out from the abutments; they were in the form of a trough open at the top and connected with stirrups to prevent spreading. A wire ropeway was used to place the various parts in position, and the ribs were tied back to the rocks with wire ropes and were temporarily stiffened; the wind-bracing was then fixed and the ribs filled in, spaces being left to act as temporary hinges. The trestles and beams were then put in place. All these parts had been previously cast on shore. The floor and hangers were shuttered and made *in situ*, the shuttering being supported on the completed beams.

Great difficulty and delay was caused by the foundations turning out quite different from expectations, and the design had to be modified, and the site altered to suit the new conditions.



View of ribs only erected.
Footbridge at Mizen Head, Ireland.

Work had to be suspended during the winter months owing to the extremely exposed position, and even in the summer there were long periods of inactivity caused by the stormy weather.

The aggregate was obtained from a very hard rock found locally, the same stone being also crushed for sand.

A road was constructed to the head by the Commissioners, but this ended at a level some hundred feet above the level of the bridge, which was approached by steps. The material had to be taken down a slope of about 1 in 1 to the site on the edge of the cliff.

Access to the island was obtained in the first place by means of ladders attached to the face of the cliff on either side, there being a narrow causeway at a lower level in one part of the gorge. Later a travelling cage was worked on the ropeway.

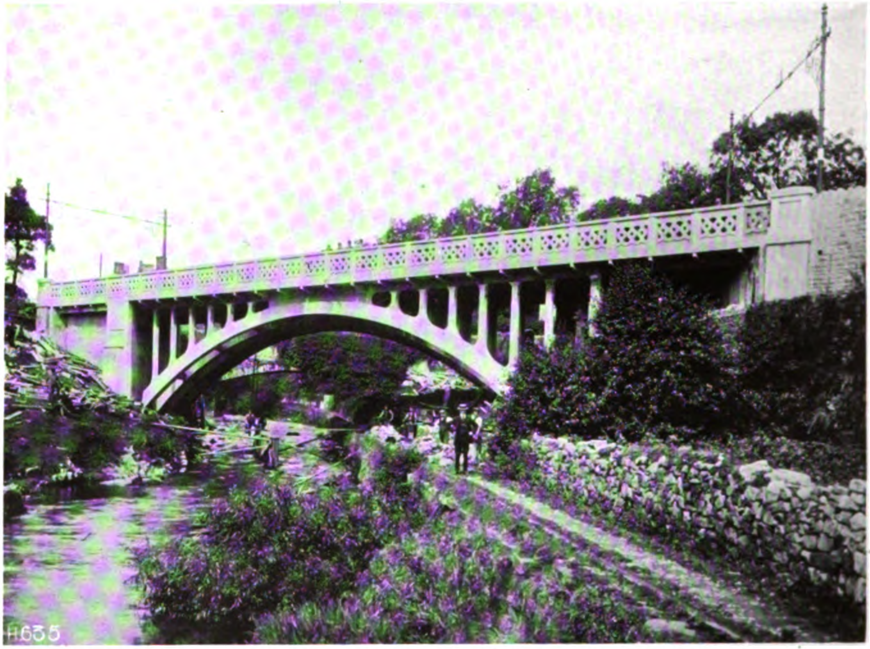
The bridge was tested two months after completion by loading with broken stone to a super load of 150 lbs. per sq. ft., the load being gradually advanced from one end until the whole surface was covered, and removed in the same way, thus testing under the most unfavourable conditions. The maximum deflection at the centre was about 1-5th in.; the bridge has also stood the test of some very heavy gales.

Mr. Philip H. Thorne, who kindly placed the information and photographs at our disposal, superintended all the erection, and local labour was employed as far as possible.

BRIDGE OVER THE TAFF AT CEFN.

THIS bridge was built jointly by the Merthyr Tydfil Corporation and the Breconshire County Council to replace a very dangerous and narrow bridge which crossed the River Taff at right angles.

The new bridge is constructed on the Hennebique system, and spans the river at an angle of 45 degrees. It was designed by Mr. T. Fletcher Harvey, the Borough Engineer to the Merthyr Tydfil Corporation, and was erected by Mr. E. H. Page, contractor, Cardiff.



BRIDGE OVER THE TAFF AT CEFN.

The wing walls were constructed of masonry. The total length of reinforced concrete portion of the bridge is 174 ft., with a width of 32 ft., which width includes an 8-ft. footpath. The surface of the road was constructed 5 ft. higher than that of the old bridge, and carried the electric tramways which connect Merthyr Tydfil with Cefn.

The centre span is 104 ft., carried by four main arch beams, supporting the roadway on spandril columns. The secondary span on the Merthyr side has straight girders supported on columns.

The specification provided for a test rolling load of 48 tons, and a static load on the cantilever footpath of 140 lb. per sq. ft.

The rolling load consisted of three steam-rollers weighing altogether 36½ tons and an electric car loaded with pig-iron and people to a weight of 15½ tons, making a total of 52 moving tons.

Eight deflection meters were used to measure the deflections caused by the passage of the load.

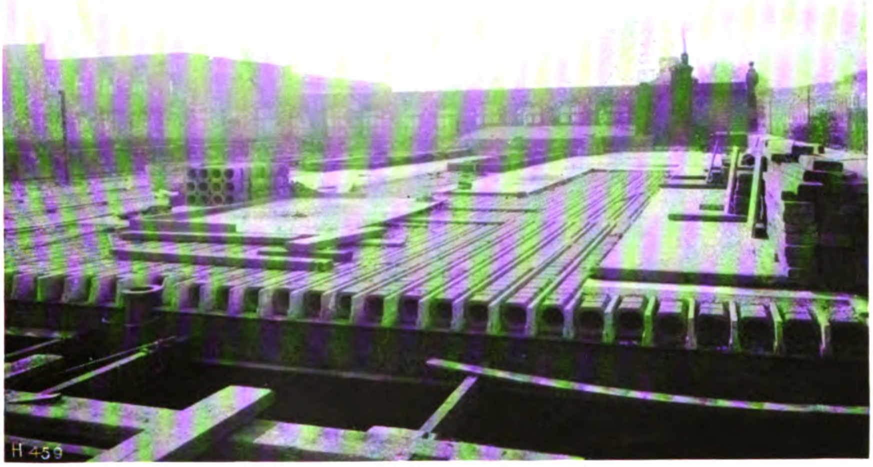
At the first trial the load was grouped together and passed over the bridge, one steam-roller leading, two following side by side, and the tramcar bringing up the rear. The load was then run over the bridge from the opposite direction. The third test was made by bringing them to rest on the centre of the span. After this two steam-rollers and the tramcar were over the secondary span of straight girders. A further static test was made upon a deck panel 6 ft. by 8 ft., and placing upon it a test load equal to 337 lb. per sq. ft.

The deflections registered were only 0.15 mm. In no case did the deflection exceed 1.2 mm. in the centre of the span. The deflections registered are only a fraction of the deflections allowed in the specification, and amounting, in fact, to 1/25,000th of the span.

The cost of the bridge was about £4,600.

ARMOURED TUBULAR FLOORS AT ALBERT FOUNDRY, BELFAST.

THE floor illustrated, which is at the Albert Foundry, Belfast, and which is some 1,200 sq. yds. in area, forms the first floor of a three-storey block and stands 19 ft. above ground, with clear spans of 16 ft. and 20 ft. It was designed for a superimposed load of 1 cwt. per sq. ft., with factor of safety of 4, the thickness of shorter spans being 9½ ins., and on larger spans, 10 ins., the mild steel reinforcement used being of the Company's patented section and the work executed throughout by the Irish Armoured Tubular Flooring Co., Ltd.



FLOOR BEING LAID AT ALBERT FOUNDRY, BELFAST.

The owners of the Albert Foundry have been so satisfied with the construction of this floor that other contracts of large area have been since executed to their order.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

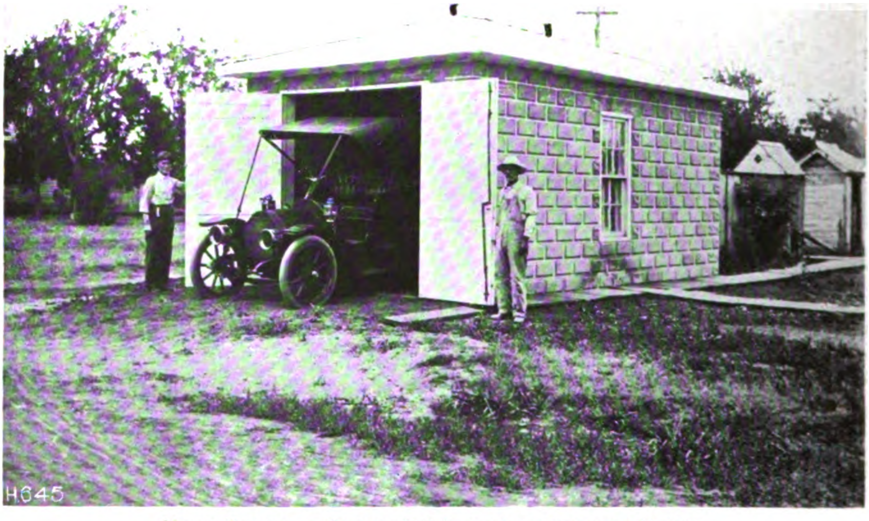
Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

CONCRETE BLOCK MOTOR GARAGE.

THE motor garage shown in our illustration is made of concrete blocks, with concrete floor and roof. The use of concrete blocks for such buildings is very advantageous where rapidity of construction and economy are of primary importance.

The garage is 12 ft. by 20 ft. by 9 ft. 4 ins., and was built for Mr. A. A. Dewey, of Cheney, Kansas, by Mr. J. E. Stanley, contractor, of the same town.

The blocks were made in two pieces, each 3 ins. by 9 ins. by 16 ins., laid in wall, leaving 4-in. air space, and connected by wire wall ties in the mortar joints, two to each block.



MOTOR GARAGE AT CHENEY, U.S.A., MADE OF CONCRETE BLOCKS.

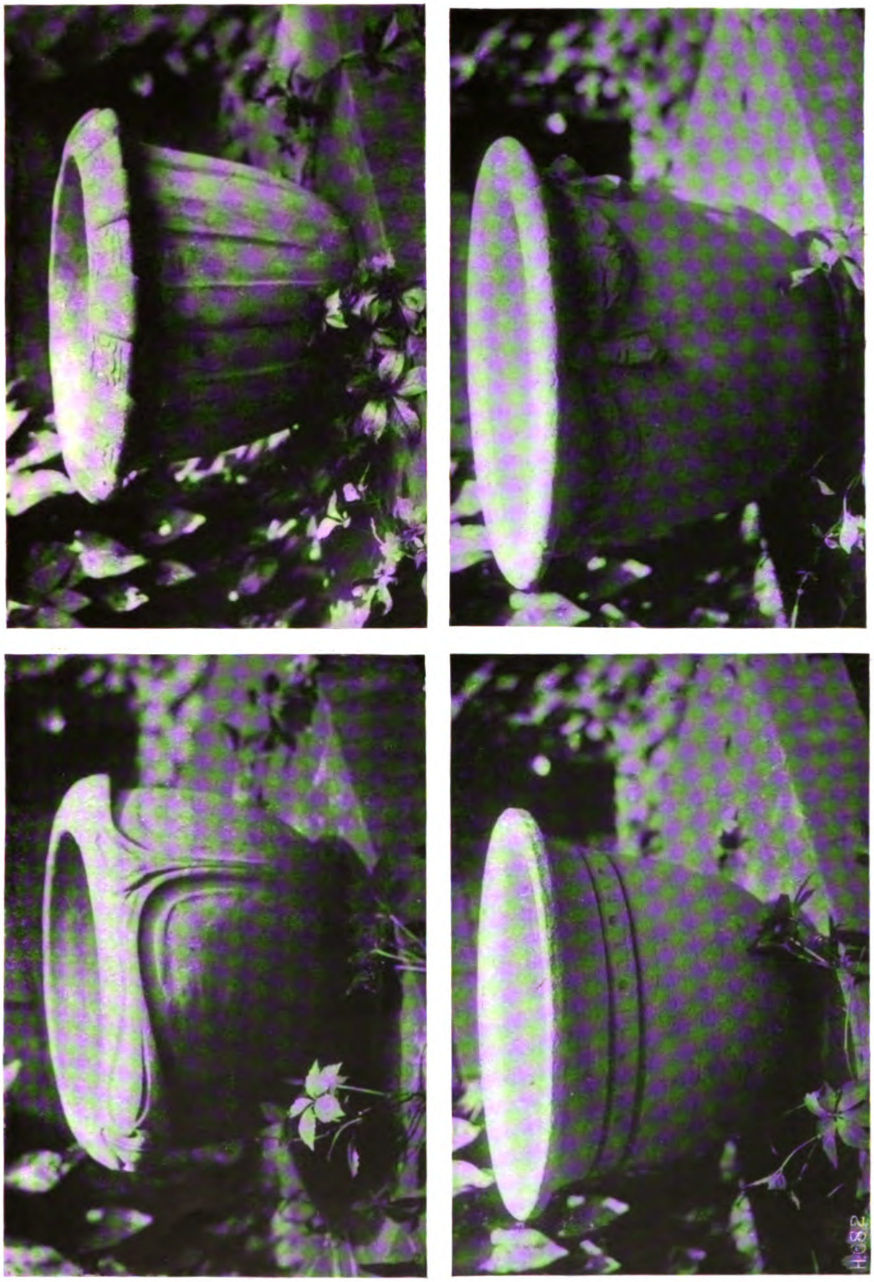
The floor is of concrete, 5 ins. thick. The roof is also of concrete, reinforced with expanded metal.

All blocks were made of 1 part cement to 5 of clean sand.

CONCRETE GARDEN ORNAMENTS.

WE have on more than one occasion referred to the development in the use of concrete for ornamental work, and the illustrations now given, which are reproductions of work of students of the School of Industrial Art of the Pennsylvania Museum, Philadelphia, show in a striking way the effective manner in which concrete can be employed for such work, as well as the advantages of using simple designs.

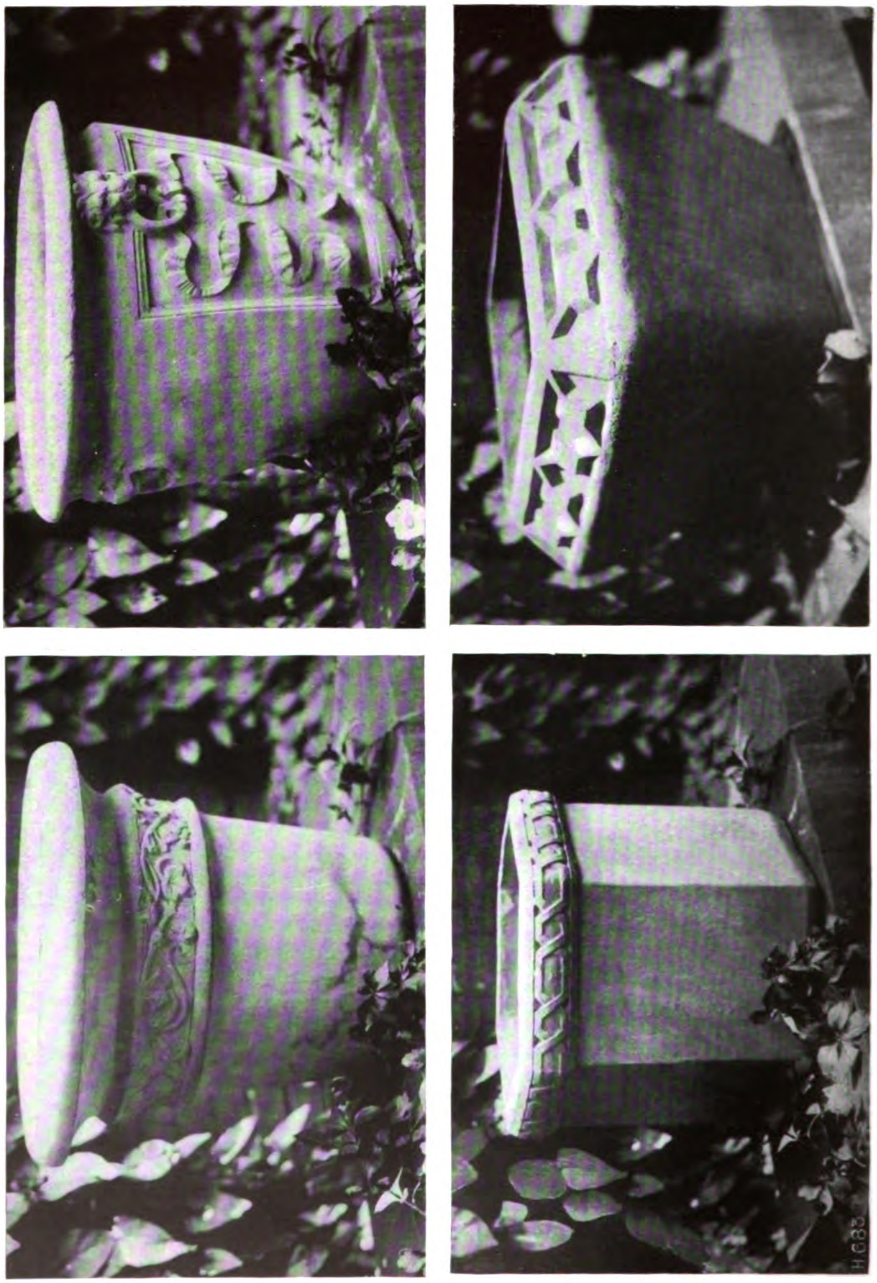
It would be well if those controlling the arts and crafts schools of this country would give some attention to the ornamental uses to which concrete can be applied,



CONCRETE GARDEN VASES.

with far greater ease than terra-cotta, and without any of the difficulties as to shrinkage that are to be met with in the latter material. It should also be remembered that concrete, if properly made to a good surface and colouring, is much more artistic in a garden than red terra-cotta.

One of the great advantages of concrete garden ornaments is that they can easily be made on the spot, whereby the cost and risk of freightage are saved. The wood moulds can be purchased and re-used many times.



Concrete Garden Vases.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the past year.

"Concrete, Plain and Reinforced." By Frederick W. Taylor, Sc.D., and Sandford M. Thompson, M.Am.Soc.C.E. Second Edition.

Published by John Wiley & Sons, New York, and Chapman & Hall, Ltd., London. Five Dollars.

Contents.—Concrete Data.—Elementary Outline of the Process of Concreting. — Specifications. — The Choice of Cement.—Classification of Cements.—Chemistry of Hydraulic Cements.—Special Tests of Cement and Mortar.—Strength and Composition of Cement Mortars.—Voids and other Characteristics of Concrete Aggregates. — Proportioning Concrete. — Tables of Quantities of Materials for Concrete and Mortar.—Preparation of Materials for Concrete.—Mixing Concrete.—Depositing Concrete.—Effect of Sea Water upon Concrete and Mortar.—Laying Concrete and Mortar in Freezing Weather.—Fire and Rust Protection. — Water - tightness. — Strength of Plain Concrete.—Reinforced Concrete Design.—Arches.—Side-Walls, Basement Floors and Pavements. — Concrete Building Construction. — Foundations and Piers.—Dams and Retaining Walls.—Conduits and Tunnels.—Reservoirs and Tanks.—Cement Manufacture.—Miscellaneous Structures. — References to Concrete Literature.—Method of Analysis.—Deduction of Formulæ for Reinforced Concrete.—Deduction of Formulæ for Chimney and Hollow Circular Beam Design.—Method of Combining Mechanical Analysis Curves.

The second edition of Taylor & Thompson's "Concrete: Plain and Reinforced" is a distinct improvement upon the first. It contains a good deal of additional information, and has been revised in accordance with the increase in knowledge since the publication of the first edition. The chief alteration is in the chapters referring to reinforced concrete, which has advanced rapidly, although the first edition appeared in 1905, at which date much was known. It is not to be expected that in a book of this nature, dealing with the whole subject of concrete in its many forms, that so much space can be given to detailed consideration as books which deal with only the one special aspect—reinforced concrete, but yet the treatment in this book is very full, and the summary is not short. Just the information needed for design is given, though, of course, other special books provide other information that is really required for the finished designer; but, still, Taylor & Thompson are a sufficient guide to enable many engineers to deal efficiently with the smaller problems of reinforced concrete design.

A new preliminary chapter has been added, in which attention is directed to many of the essentials of concrete construction, and the reader is warned against the serious errors that have frequently been made in the field.

In the chapter on reinforced concrete design the treatment of shear and diagonal tension is good, attention being properly called to the difference between pure shear and shear in beams as a measure of diagonal tension. For instance, 60 lb. is often suggested as the permissible shear stress in beams, but this only applies to rectangular beams with longitudinal rods alone, without stirrups or inclined members. When, however, the direct shearing at the point of support or along the plane of connection between the slab and rib of a T-beam are concerned the value should be much higher, the pure shearing resistance of concrete being about $\sqrt{tc}$ where $t=$the tensile resistance and c the compressive resistance of the concrete, or as $t=$about $\frac{1}{10}c$ we get the shearing resistance as $\frac{1}{3\cdot16}c$, the compressive resistance. Therefore, if this latter is taken as 600 lb. sq. in. we ought to adopt about 190 lb. sq. in. as the value in pure shear. The treatment of bending moments on continuous beams is also noteworthy. The designs of flat plates and columns are dealt with in detail, and notes are included on many smaller details. A complete example of floor design worked out in detail with the formulas in the book is useful practice for the student.

Retaining walls, footings, culverts and chimneys are also treated, and Prof.

Frank P. McKibben contributes an interesting chapter on arches.

The information on plain concrete has been brought up to date in many directions and the book on the whole is most praiseworthy. It should be in the possession of everyone interested in concrete.

"The Modern Manufacture of Portland Cement." By Percy C. H. West.

Published by Crosby, Lockwood & Son, London, 1910. 12/6 net.

Contents : ***Book I., Wet Process.***—Wash Mills. — Wet Edge-Runners and Stone Mills.—Wet Tube Mills.—Other Wet Mills and Accessory Plant.

Book II., Dry Process.—Introduction.—Crushers.—Driers. — Millstones, Edge-Runners, Disintegrators.—Ball Mills. — Centrifugal Roll Mills.—Tube Mills.—Conveyors and Elevators.—Dust Collectors.—Weighing Machines.—Separators and Automatic Feeders.—Pressing and Drying Briquettes.

Book III., Kilns. — Shaft and other Stationary Kilns.—Rotary Kilns.—Coal Drying and Grinding.

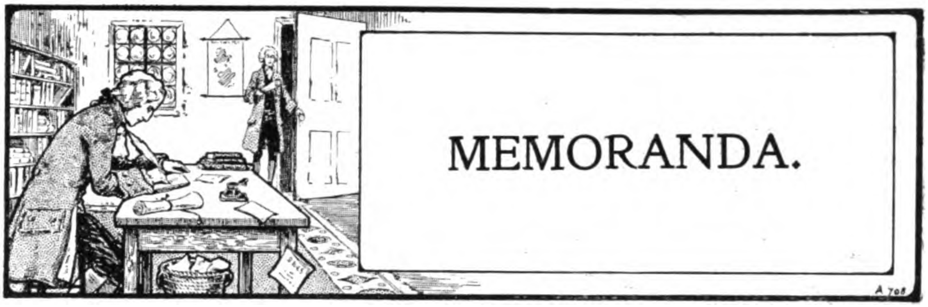
Book IV., Treatment of the Clinker and of the Finished Cement.—Storing and Grinding the Clinker.—Warehousing and Packing the Cement. — Description of some Modern Cement Plants.

Mr. Percy C. H. West has written an interesting book on the modern manufacture of Portland cement, which he describes as a handbook for manufacturers and users and all interested in the product. The work is something more than a handbook, and will serve as a welcome addition to the literature on the subject. It is to be regretted that Mr. West has touched so lightly upon the historical side of the industry, but probably he is of opinion that this aspect has already been sufficiently dealt with in existing works. On the all-important practical side, however, the present volume is full of information of considerable value to all engaged in the manufacture of the article. It is, as the author claims, a description of the modern machinery at present employed in the various manufacturing operations, and there would appear to be no item of plant in use at any works which fails to receive some attention at the author's hands. The first and second sections of the book deal with the two great branches into which the manufacture is divided—viz., the wet and dry processes respectively; the third section is devoted almost entirely to the question of kilns and everything appertaining thereto, and although, naturally, the rotary type comes in for the greatest attention, the various forms of shaft and other stationary kilns are fully described, and their good as well as their weak points are commented upon. The remaining section relates to the grinding of the clinker and to the finished cement. In the preface to the present volume the author states that in a separate volume, now in course of preparation, he hopes to deal with the chemical and physical testing of the raw material and the finished product and the general control of the manufacturing process. The results of recent research and the scientific side of the subject will also be treated at length. The present volume is well printed and illustrated. A perusal of it brings home to one the somewhat disagreeable reflection that the designs for works and the supply of the great variety of machines used in the industry are largely in the hands of manufacturers outside the United Kingdom.

"Encyclopædia of Municipal and Sanitary Engineering." By Maxwell & Brown.

Published by Constable & Co., Ltd., London. £2 2s. net.

There is obviously a place for an encyclopædia of municipal and sanitary engineering, and the only query is as to whether this attempt to provide the needed information is sufficient, and whether the volume is really useful in the way intended. The list of contributors assures us that the information must be reliable in itself, but will it be useful to the municipal engineer? On inspection of the book we find that though the information is necessarily scrappy by reason of the limits of size, yet the salient points are obtainable on most subjects. We may concern ourselves with the information that is furnished on the special subjects with which we deal. We find that Prof. Henry Adams deals with Portland cement and concrete, concrete dams, reinforced concrete and retaining walls, and his notes on these subjects are to the point. They do not, of course, deal very fully with the subjects, but they give a general idea of the principles of design and practice, and the engineer who refers to them will be put on the right track for dealing with the problems of everyday work.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

SOUTHAMPTON DOCKS WORKS.

Visit of the Concrete Institute to Southampton.—A visit to Southampton Docks was paid on Saturday, October 15th last, by the Concrete Institute, and various engineering works in progress and completed at that port were inspected. The party travelled from Waterloo Station, and were met at Southampton just before noon by Mr. F. E. Wentworth-Sheilds, M.Inst.C.E., the Docks Engineer, who at once conducted them to Messrs. Harland & Wolff's works, where by the courtesy of the manager, Mr. R. Crighton, they passed through the fine workshops that this firm have recently built for carrying out large and small repairs to vessels.

Thereafter a visit was made to the works of constructing the new 16-acre dock, which measures 1,700 ft. long by 400 ft. wide. It is in this dock that the new monster vessels of the White Star Line—the *Olympic* and *Titanic*—will be berthed. The main walls of the dock are constructed of mass concrete, 73 ft. high from cope to foundation, and the depth of water at low tide will be 35 ft., which can eventually be increased to 40 ft. The depth at high water is 13 ft. more. There is no entrance lock, and the largest vessels will be able to pass in and out even at low water. Four outside quays are also being built of lengths varying from 500 ft. to 700 ft., and with a minimum depth of 25 ft. to 32 ft. The site of the new dock a few years ago was a mudland covered by every high tide. The greater part of the basin has been built in the dry under the protection of an old enclosing bank, which kept out the river water. Within it excavation has been carried to a depth of 45 ft. by means of steam navvies, the bulk of the spoil being conveyed to sea, for which purpose it was hauled up by a rope railway on to a tipping stage 375 ft. long and 40 ft. high, and from there shot down into steam hoppers, which took it to the far end of the Isle of Wight—a distance of 25 miles—and discharged it into the sea. The walls of the main basin have been built in timbered trenches carried down to the full depth of 73 ft. below quay level, and the dock walls have been constructed within these trenches of Portland cement concrete mixed by standing machines of the Messent and Smith types, the concrete being conveyed to the trenches and deposited by cranes and goliaths behind shuttering. This stage of the work has now been completed, and the enclosing bank removed and water let into the dock, which is now being deepened by a large dredger and three grabs. The portions of the eastern and of the western walls which pass through the enclosing bank is now being constructed. On the eastern side a length of the wall is being built inside box dams, formed of close timber sheet piling. These box dams have been carried down to dredging level, and the foundation of this portion of the wall is being formed of reinforced concrete caissons, sunk to 16 ft. below the dredging level.

On the western side the entrance wall is being formed in deep water without enclosing dams of any sort. It was this work which attracted the chief attention of the Concrete Institute's members. Firstly, a cut has been dredged down to the level of the wall toe, and below this the foundations have been put in in timbered trenches, formed by driving sheet piling in front of and behind the site of the wall. The clay between the timbering is then removed by means of steam grabs working off a temporary stage. When the foundation level of the wall is reached it is carefully cleaned by helmeted divers. During this process of grabbing out the soil between, the trench is supported by special struts fixed at regular intervals by the divers, these struts not being fixed by the usual folding wedges, but by an expanding screw joint specially designed to be easily manipulated under water. Within the trench the foundation of the wall is built of mass concrete, lowered down in special boxes by Titan cranes, these boxes having doors at the bottom, which are unlocked only when they have rested on the bottom, the concrete being dropped out when they are lifted, and thus not discharged through the water. Above the dredging level the wall consists of large 8-ton concrete blocks at face and back, set on the foundation of mass concrete, and the space between these blocks is in turn filled in with a hearting of mass concrete.

Two outside quays, extending from the new dock entrance up to the Trafalgar Graving Dock, have been built in deep water in a similar way to the wall just described, and another outside wall has been built to the south of the dock entrance in large box-dam trenches.

After lunch the Concrete Institute's party embarked on a steam launch and viewed various completed works about the docks, attention being particularly directed to the reinforced concrete jetties on the docks, in one of which there has been considerable deterioration, due to electrolytic action. Across the water was seen Messrs. Thornycroft's jetty, which, though built 11 years ago, is in perfect condition.

The party then went on board the Union-Castle Mail Steamship Co.'s R.M.S. *Briton*, by the kind invitation of the managers of the line, and had tea on board. They then embarked on the launch again and went round the docks, viewing the new 16-acre dock from the water as they had done from the land in the morning.

GENERAL.

Papers at the Town Planning Conference.—The papers at the Town Planning Conference, though having no direct bearing on structural problems, must claim the attention of all interested in structural work, and we, therefore, give below a list of some of the more important papers, referring our readers, however, to the very excellent Conference literature, which can be obtained—even now after the event—by individuals becoming enrolled as members of the Conference, and requesting the printed matter that has been issued.

The inaugural address, delivered by the Rt. Hon. John Burns, M.P., President of the Local Government Board, claims attention ; also the following papers are of primary interest :

" The Growth of Legal Control over Town Development in England," by Mr. H. Chaloner Dowdall, M.A., B.C.L.

" Notice sur Les Architectures Obligatoires dans La Ville de Paris," by Monsieur Louis Bonnier.

" City Improvements," by Professor S. D. Adshead, F.R.I.B.A.

" Greater London," by Mr. G. L. Pepler, F.S.I.

" The City Development Plan," by Mr. Raymond Unwin.

" City Development," by Mr. W. E. Riley, F.R.I.B.A.

" Recent Progress in German Town Planning," by Dr. Ing. H. J. Stübben, Geheimer Oberbaurat.

" The Town Planning Act and Open Spaces," by Col. Eustace Balfour, A.D.C., F.S.A., F.R.I.B.A.

" The Federal Capital of Australia," by John Sulman, F.R.I.B.A.

" Town Planning in Relation to Old and Congested Areas," by Mr. Arthur Crow, F.R.I.B.A.

University of London and Reinforced Concrete.—A course of five lectures, addressed to advanced students of the University of London and others interested in the subject, will be given by Mr. William Dunn, F.R.I.B.A., at the Institution of Civil Engineers, Great George Street, Westminster, at 5.45 p.m. on Fridays, November 4th, 11th, 18th, 25th, and Wednesday, November 30th, 1910. The chair at the inaugural lecture will be taken by Sir Henry Tanner, I.S.O., F.R.I.B.A.

The syllabus of these lectures is as follows :

> On patents—concrete for various purposes—columns and compression members—longitudinal reinforcement—lateral reinforcement in various forms—column footings and other details—on beams and reinforcement to resist bending—labour-saving tables—shearing and shearing reinforcement—retaining walls—dock walls and jetties—bridges—girder bridges—arch bridges—failures in reinforced concrete—quantities and cost data, etc.

In addition to the lectures, a demonstration will be given at University College, showing the manner of failure of reinforced concrete columns and beams in the testing machines.

Admission will be by ticket, obtainable on application to Mr. P. J. Hartog, Academic Registrar.

Large Reinforced Concrete Bridge in New Zealand.—The contract has recently been let for a large bridge in New Zealand, consisting of 25 spans, each 41 ft. long. The structure is to be built on the Paragon reinforced concrete system, the patents of which are controlled by the British Reinforced Concrete Engineering Co., Ltd., Deansgate, Manchester. The arched ribs are sprung from framing, which again is supported on reinforced concrete piles driven to hard strata. The structure is to carry heavy traffic, and will involve the use of from 300 to 400 tons of steel, in round bars from ⅜ in. to 1¼ in. diameter, for reinforcing. In this system of construction stirrups of the fixed type are sprung on to the tension bars by squeezing their arms. These, when released, retain a tight grip on the bars wherever placed, and tend to become tighter when the concrete is rammed. The arrangement, besides having proved itself efficient, is economical, as a commercial section of tension bar is used. The stirrups distribute the stresses along the full length of the beam or slab, ensuring that the concrete and steel act together in taking the load. Both in the piles and columns a sufficient number of hoops is made, with encircling fitments, to take the vertical bars, and hold them in their correct positions relatively to one another without the aid of wedges or struts, which are liable to be knocked out in consolidating the concrete. In addition, the ends of the hoop rods and helical wrappings are arranged to lie in the core in such a manner that not only are they securely anchored in the concrete, but the core is bonded at intervals in every direction against the bulging action set up under heavy loading.

The Effect of Frost on Freshly-Mixed Concrete.—In view of the fact that freshly-mixed concrete, which has frozen and again thawed before setting in place, is commonly believed to be useless, a number of experiments for the purpose of testing this point have recently been conducted by Prof. H. Burchartz, at the Royal Testing Station of Gross-Lichterfelde, Berlin. The results show that mortar and concrete, if allowed to warm up again to the ordinary temperature before setting in place, are very little affected by a few hours' freezing. The setting time is little altered, although, if the temperature of laying the mortar is low, the setting is, of course, greatly retarded. Prolonged freezing, continued for several days, prevents the mortar from hardening properly, dry mixtures suffering more than wet. For example, the 28-day strength of 1 : 3 briquettes was found to be only 40 per cent. of its normal value after 3 days' freezing (followed by thawing) if mixed comparatively dry, but 62 per cent. of its normal value if mixed wet. The effect on 1 : 5 concrete was still greater, the strength of the dry concrete falling to 14 per cent., and that of the wet concrete only to 67 per cent. Against this, however, must be set the much greater strength of the dry concrete under normal conditions, the difference quite compensating for the apparent advantage of the wet mixture.

The Use of Concrete in Mining. - On the Rand, concrete is coming largely into use at the newer mines in connection with kingposts for batteries, and in other fields it is being used in conjunction with tubing for shaft sinking. Considering the scarcity and high price of timber, concrete alone or strengthened by iron framework will no doubt be much more largely used in mining work both on the surface and underground than has been the case in the past. We believe the coal mines of this country might

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May we send you our catalogues, you will find them interesting even if you have no requirements in this direction at the moment.

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make much more use of concrete than they do at present with a saving in costs, as concrete is cheap here and lasts longer than even the hardest timber.

The Tiverton Water Supply.—We observe the following in our contemporary *The Surveyor,* of September 2nd :

> "Mr. J. Siddals, Borough Surveyor of Tiverton, states in his report for the year which ended with March 31st last that plans have been prepared and tenders obtained for new concrete service reservoirs and other works in connection therewith at Allers and Warnicombe. Alternative tenders for reservoirs in ordinary solid concrete and in reinforced concrete were obtained, but partly in consequence of the short period for which the Local Government Board grant loans for the latter description of work, the Council after consideration decided to adopt the principle of solid concrete construction and provisionally accepted the tender of Mr. E. J. Coles, of Taunton, at a sum of £2,278."

This does not speak well for the Local Government Board. It would seem that that Department continues to remain a full decade behind the times, as far as reinforced concrete is concerned.

Lining an Irrigation Canal with Cement Plaster.— 2,640 ft. of masonry lining in the Community Ditch, an irrigation canal of 650 ft. capacity at Eldorado Springs, Denver, U.S.A., was completed in March, 1909, but was so carelessly built as to be useless in September of the same year. In order to repair this the joints were first picked out and the wall thoroughly washed with a hose, when the joints were re-jointed with 1 to 3 cement mortar. The first coat of ¾-in. cement mortar was put on with plasterers' and masons' trowels after the wall was well wetted, and then floated with wooden floats. After setting four to six hours, the second coat was applied and floated in the same way. The plaster was kept wet for two or three days after. An inspection in May, 1910, showed the ditch in splendid condition after five months' hard wear. No signs of pulling away were found in the plaster, but five contraction cracks appeared at points of tangent, and these have silted up. The conclusions drawn by the writer in *Engineering-Contracting* were :

1. The addition of lime— hydraulic, hydrated or otherwise—to cement plaster or concrete is neither economical nor beneficial.
2. Cement plaster is the cheapest and most satisfactory method of lining and waterproofing earthwork or masonry ditches.
3. Cement plaster can be made permanent on masonry or concrete, no matter how old, by (*a*) thoroughly washing the surface to remove all dust and dirt; (*b*) having surface well soaked; (*c*) thoroughly floating to get plaster as dense as possible and ensure good contact by expelling all air.
4. No need for acid washes to ensure a good bond.
5. A thick coat of grout wash is sufficient protection for concrete and plaster against a fairly heavy frost.

TRADE NOTICES, CATALOGUES, ETC.

Lock Woven Mesh System.– Messrs. James H. Tozer & Son have sent us the following list of orders for their lock woven mesh and contracts executed and in course of erection : Retaining wall at Dollis Mount, Middlesex County Council ; floors and roof at St. Anne's Clergy House, Soho, W. Courtenay Le Maitre, Esq., architect ; floor at Hull, D. Christie, Esq., Architect ; floor to Retort House at Gasworks, Guildford ; floor at Bo'ness for Messrs. Baikie & Sellar ; floor at Windsor for Mr. R. Foreman ; bridge at Bishop's Castle, Salop, Clun Rural District Council, A. Harmar, Engineer ; floors to cottages at Halkyn, Flintshire.

The Expanded Metal Company's Pamphlet, No. 2.—We have received a most usefully compiled booklet from the Expanded Metal Co., entitled "Expanded Steel for Reinforced Concrete Construction," which comprises some 240 pages of practical matter, well illustrated and edited. The application of expanded metal to general constructional and civil engineering work is too well known for us to enter into in detail, and we have from time to time illustrated some of the excellent examples of work presented in this pamphlet. There are, however, several novel features in the way of new uses for concrete which we hope to deal with at some length in the near future. We would also particularly point out pages 21 to 24 of the pamphlet, which give the result of some highly satisfactory tests undertaken by the company at the British Fire Prevention Committee's testing station, and it speaks well for the success of the company that they should have been, so far back as 1899, one of the first industrial firms to have a floor scientifically and independently tested in this country as to its resistance against fire. These tests, by the way, were repeated on a much larger scale in 1906, and on that occasion the firm in question obtained the standard classification of "Full Protection," Class B, on a 4 hours' test, when the floor, some 20 ft. by 10 ft., well loaded, passed with eminently satisfactory results. Particulars are also given of various tests to ascertain the tensile strength of expanded metal, as well as of tests on expanded steel-concrete slabs. Altogether the pamphlet in question is a most useful one, and should be of great interest to our readers.

Standard Specification for Portland Cement.—We have received a copy of a diagram arranged by Mr. D. B. Butler (Messrs. Henry Faija & Co.), in conjunction with Mr. G. J. Fenwick, for ascertaining at a glance from the analysis the hydraulic modulus or ratio of lime to silica and alumina in accordance with the recently issued revised British Standard Specification for Portland cement. As the specification stands an elaborate calculation is involved in order to ascertain this ratio, and the usefulness of Mr. Butler's diagram becomes apparent when it is stated that by its means a determination can be made in 15 seconds as against 5 to 10 minutes in working out the calculation in the ordinary way. The diagram will doubtless be of real use to engineers, architects, and contractors, and, in fact, to all users of Portland cement, as well as to the manufacturers of the product. It is published by Messrs. John J. Griffin & Sons, Ltd., Kingsway, W.C., mounted on stiff cardboard, 22 ins. by 17 ins., at 2s. 6d. net.

Mr. Edmond Coignet has been awarded a "Grand Prix," Class 28, at the Brussels Exhibition, 1910, for his system of reinforced concrete.

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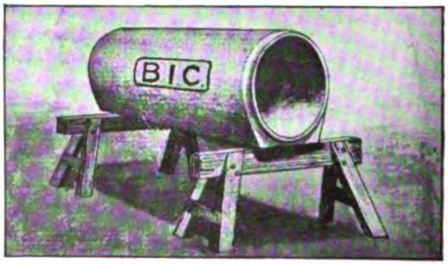

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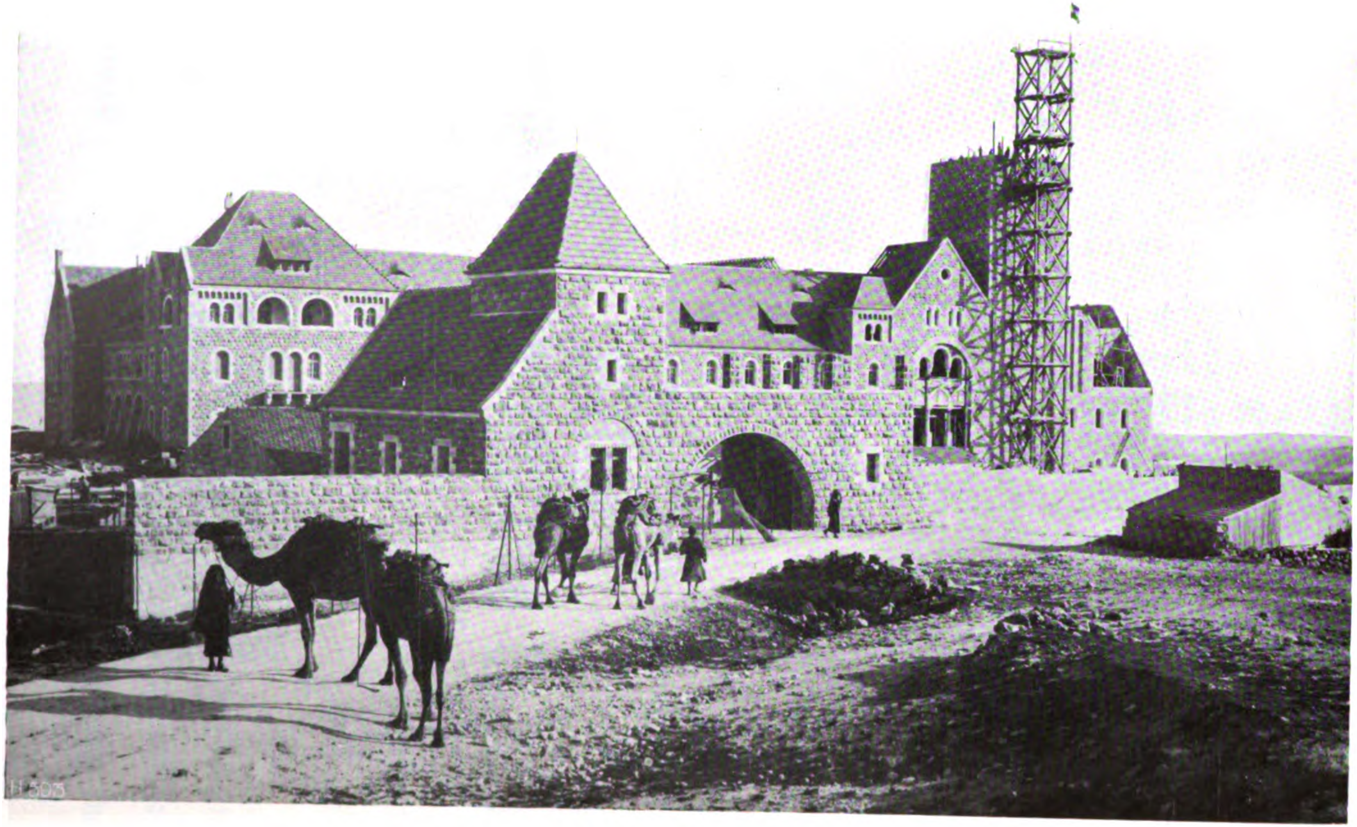


Floors and stairs of concrete.
German Sanatorium in Jerusalem.

(Photograph by
American Colony, Jerusalem)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume V. No. 12. LONDON, DECEMBER, 1910.

EDITORIAL NOTES.

THE NEW CITY BRIDGE AND REINFORCED CONCRETE.

THE Corporation of the City of London are considering schemes for a new bridge for the Thames. At present their deliberations are mainly concentrated on the exact line to be taken by the bridge and its approaches, but the time will soon arrive when the design of the bridge proper will have to be under review.

For reasons of sound construction, economy in first cost, and very material saving in maintenance, we would urge upon those controlling the matter a most careful investigation into the advantages of using reinforced concrete for the new bridge.

There are a large number of very excellent bridges of artistic design that have been executed on the Continent of Europe and in the United States, and although we cannot point to any great reinforced concrete bridge in this country, there are a great number of smaller ones, which amply prove our contention as to the utility of the material for the purposes named.

Some of the more perfect specimens of large span bridges in France, Germany, Austria, Italy and the United States show what can be effectively and economically done with all due regard to architectural pretensions.

The incessant painting of steel bridges means annual expenditure of considerable amounts. Masonry bridges generally mean a first cost of great magnitude. Why should not the Corporation of the City of London do what is most practical and economical, and set an example to the Empire in making use of a material which has been amply tried for an undertaking of this description? The non-employment of reinforced concrete would simply indicate a continuance of that meaningless conservatism which exists in certain departments of the Corporation's work and by no means tends to uphold the prominence of the City of London in municipal matters.

To be ultra conservative on a technical question of this kind would do infinite injury to our engineering prestige abroad.

THE APPLICATION OF THE RECENT AMENDMENTS TO THE LONDON BUILDING ACT.

IT will be remembered that the Parliamentary Summer Session of 1909 gave the London County Council powers to frame regulations on reinforced concrete under a certain amendment of the London Building Act. With the appearance of this issue of our Journal the year 1910 is practically ended without those regulations having been definitely framed, much less having found a place on what we will term the "statute book." We do not believe that the proposals have even yet been formally submitted to the Local Government Board which authority has a voice in the matter.

AN AMENDMENT ACT THAT IS NOT BEING DILIGENTLY APPLIED.

We do not in any way wish to condemn the London County Council for any delay in this matter, but we have before us the very unfortunate example as to the dilatory application of powers obtained some four or five years back for the safety of life in buildings, which powers have not yet been properly put in force, and we think it is time that a reminder were published, as both the general public and the technical professions do not appreciate any unnecessary postponement in matters of this kind.

In the procrastination of applying its powers as to safety of life from fire, the conduct of the London County Council is, of course, quite inexcusable. We do not know exactly where the fault lies, but it is certainly not to be attributed in the slightest degree to the Superintending Architect or to his assistants, nor to the district surveyors, for all these officers have the safety of the public very much at heart, and they fully realise the dangers to life that could be easily avoided if the powers in existence were enforced.

We fear, however, that it is mainly—if not solely—a question of injudicious economy, combined, perhaps, with the fact that the members of the County Council controlling the matters do not happen to be of the same municipal party that so ably fathered the excellent enactment under which the powers were taken. Those who are behind the scenes and feel strongly on the matter go so far as to say that the party in office fear that if the powers were applied there would be a diminution in the votes obtainable by them from the small shopkeeper class, who would be affected by the proper enforcement of the existing enactments in question, but we cannot imagine that any question of votes would influence a county councillor in a matter of this kind, particularly when he has before him the series of shop fires—some of them fatal—which have unfortunately occurred during the last two years.

In any case the matter requires looking into, and although we differ at times with the Local Government Board, we believe that this is a case where that Department might inquire why an enactment, obtained at considerable expense for the benefit of the community several years ago, has not yet been put in force, especially as we know that the necessary preliminary work of scheduling the property affected has long been completed and probably paid for.

L.C.C. REGULATIONS ON REINFORCED CONCRETE.

But to revert to our primary point on this occasion—viz., the delay in preparing regulations as to reinforced concrete—this is not, we think, a matter in which the Building Act Department of the County Council should be blamed. We fully realise that the Council's officers must tread warily in preparing the regulations. They have to meet an extraordinary amount of prejudice from the ignorant and ultra-conservative older members of technical professions. They have, too, to meet an extraordinarily virulent opposition on the part of certain societies that always systematically find fault with anything done by the County Council and its Building Department in particular. Lastly, they are "up against" the vested interests of the industry concerned—*i.e.*, the reinforced concrete specialists and the contractors, some firms in particular fearing that the rules may interfere with their pet principles of design and practice. Thus, taken all in all, the difficulties of framing suitable regulations are by no means inconsiderable. But surely the County Council should support its officers, and if anything give them every facility and assistance to accelerate their work with the full knowledge that they are at one.

THE PRELIMINARY DRAFT REGULATIONS.

It is an open secret that the London County Council has prepared a preliminary draft of the regulations it desires to see put in force, and whilst we realise that there is much disagreement as to their context among the many parties who have had the proposals under review, we would like to say that, taken as a whole, we find them equitable and generally satisfactory, in fact, a reasonable compromise as between the conflicting interests and views, theories and actualities, pessimism and optimism, expressed in the many communications we have received on the subject. The draft is naturally not yet a perfect one, and it obviously shows a few blunders, some mathematical, some clerical, but these it should be easy to remedy.

THE NECESSITY OF GREATER FIRE-RESISTANCE.

Only on two points would we take exception to the general trend of these draft regulations. Firstly, we do not consider that they are sufficiently precautionary from the fire point of view as far as protective covering of the metal is concerned. To allow floor panels to be passed if there be but half an inch protection below the metal work is not in accordance with common sense. Facts speak quite strongly that half an inch is quite insufficient, and we would only point to the results of several tests of the British Fire Prevention Committee, which show most clearly the folly of so small a dimension. Where a concrete of the much-favoured ¾-in. aggregate is used a covering of half an inch is insufficient for purely practical reasons, but from a fire point of view nothing in the form of a covering, not even in a floor panel of 10-ft. span, can be considered a moderate fire resistant that is under 1 in. in thickness—*i.e.*, 1 in. excluding any possible covering of plaster, which plaster almost invariably flakes off on the application of but slight heat. On the lightest of girders the protection should be 1½ in.

THE UNNECESSARY EXCLUSION OF COKE-BREEZE.

The second point to which we take exception is the proposed entire ruling out of slag, clinker, coke-breeze, etc., as aggregates. This seems unwise. No journal can be better informed than ours as to the risks to be considered in these and other aggregates. Good coke-breeze, though, of course, not suitable for compression, is an excellent filling, and a first rate protective covering, probably the most fire resisting obtainable, and there does not appear to be the slightest reason why it should not be freely used for that purpose. A good, well-washed selected slag or clinker can also be recommended. The risk of its chemical effect on the reinforcement is infinitesimal.

Except regarding this generalisation as to aggregates, the criticisms that the regulations are too strict, are, we think, entirely misplaced, if anything the proposed rules require stiffening in one or two directions in order to discount possible poor workmanship. As to the movement of adopting the Royal Institute of British Architects' recommendations as standard regulations, we fully appreciate the desire for uniformity, but the recommendations do not go far enough, and they do not lend themselves to legislative enactment as they stand. They are a useful guide, and we think that the principles they embody have been very rightly largely applied in the draft regulations, but to try to adopt them bodily would be impracticable.

THE DRAFT REGULATIONS AND THE TECHNICAL SOCIETIES.

We would not have referred to the draft regulations, which were originally intended to be confidential, had they not reached a very wide circle and been the subject of a conference called by the Royal Institute of British Architects. The views of that institution cannot be considered friendly to the Superintending Architect, and it aspires to lead the other societies concerned in the direction of unreasoning opposition. The other societies affected—more particularly the Concrete Institute—are strong enough to act independently, and they should assist in getting London some useful regulations instead of helping to oppose them *in toto*.

THE NECESSITY OF A STRONG POLICY IN THE L.C.C.

But to revert to our original complaint as to loss of time. In our view the delays arising from preliminary drafts, conferences, and the like, are only excusable when the County Council are desirous of smoothing over rough edges whilst supporting the principles laid down by their officers. When the delay, however, appears to afford an opening specially created by the Council to enable it to weaken the proposals of its officers, then the delay becomes a scandal.

The Local Government Board, will, however, no doubt prevent too great harm being done by the " wobbling " of non-technical county councillors, and they will realise that the Architects' Department is reasonable in its demands. The Board, by the bye, is fully entitled to alter any proposals, and its reputation is not in the direction of leniency *re* reinforced concrete, so that the opponents to the draft regulations may even find their wings slightly clipped if they enter the fray against the County Council in too virulent a manner.

But, again, how about the enforcement of the Building Act Amendment Act of some years back ?

CONCRETE IN FARM BUILDINGS.

THE plague of rats in certain of our rural districts has again brought to our notice the extraordinary misuse of timber in modern farm buildings, more particularly for the floors of such structures whereby a hollow space is generally left below the boarding.

In all new farm buildings concrete floors should be employed. They are more sanitary and satisfactory in every respect, and more economical in the long run; but where the presence of vermin is to be anticipated concrete is almost an essential.

As far as existing buildings are concerned we can only recommend owners to rip up their floors, fill in the space below, and put down floors from 4 in. to 6 in. of concrete, reinforced—where there are large areas to be covered—with some light form of metal reinforcement.

A suitable aggregate can generally be obtained on, or in the close vicinity of, farms, and thus there should be no difficulty in employing rural labourers. The only thing that has to be brought by rail or boat is a comparatively small quantity of good British cement, which can be used in the proportions of 1 to 6, or even 8. Cheap foreign cement should, however, be carefully avoided. It frequently gives trouble, as it is too often a Belgian " natural " cement.

BELGIAN CEMENT TRADE.

SIR CECIL HERTSLET'S annual reports on the trade and commerce of Belgium are always interesting, and are of real value to the commercial community at large, for it is his practice to deal in a thoroughly exhaustive way with all branches of the subject. But naturally his reference to the cement trade in the report now published for the year 1909, and the first half of 1910, is of very particular interest to the readers of this journal.

It appears that the cement trade in that country, which for some time past had been in anything but a prosperous condition, developed an undoubted improvement during the past year, and this has continued throughout the present year, with the result that prices have appreciably advanced all round, with a further increase in prospect owing to the enhanced cost of fuel, etc. It is satisfactory to note that the United Kingdom has for a considerable period drawn less of its supplies from this quarter than was formerly the case, and as the exports from Belgium to this country are exclusively of the " natural " type, or what we call " fictitious " Portland cement, it is a matter for real congratulation.

The enormous reduction in the imports to our markets may be attributed largely to the fact that consumers are now thoroughly alive to the danger of using this inferior product, and also, of course, in some measure to the widespread adoption of the British Standard Specification, the insistence upon which is an effectual bar to the use of the material. Other markets, therefore, had to be sought, and large quantities are now being exported to certain Continental countries and to the South American Republics, while South Africa and Egypt appear to be receiving considerable quantities.

It would not be altogether surprising if the greater activity in trade, which has recently arisen in the United Kingdom, and which has resulted in a better demand for *genuine* artificial Portland cement, with an improvement in prices over those quoted during the recent period of depression, should tend to stimulate the importers of Belgian "natural" cement to renewed efforts to regain their lost hold on our home markets. It, therefore, behoves all users of cement at this juncture to be on their guard, and to insist that their cement shall conform at least to the requirements of the British Standard Specification, which has been settled by the best expert opinion in this country, and adopted almost without exception by all large consumers.

CEMENT MORTAR *versus* LIME MORTAR.

SIR CECIL HERTSLET also points out in his report that builders in Belgium are now beginning to use cement mortar in place of lime mortar, " the former being no more expensive." It has been contended for years past by the leading authorities in this country, and notably by Lord Cowdray (better known, perhaps, as Sir Weetman Pearson) that cement mortar is as cheap as, if no cheaper than, lime mortar ; whilst in the former case strong, solid work is absolutely assured, whereas, as is generally known, lime is to some extent an uncertain factor. In the former case 6 to 8 parts of sand can be used to 1 part of cement ; while in the latter case 3 to 4 parts of sand at the most is the maximum that can be used with one of lime. Lord Cowdray gave public utterance to this opinion some two or three years ago, and added that once this far-reaching and important fact is known, the use of cement mortar for all purposes will largely displace lime.

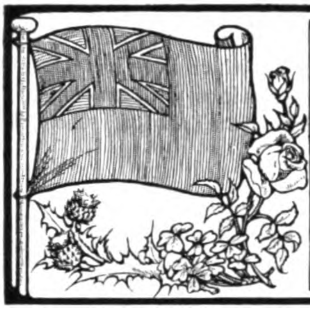
Engineers and architects in view of this would, therefore, be acting in the nterests of sound and solid work if they specify for all operations in which they are interested the use of cement instead of lime for this purpose.

OUR NEW INQUIRY AND CORRESPONDENCE COLUMN.

WE would notify our many correspondents that with our next issue, January, 1911, we have arranged to publish an inquiry column.

Since this journal was started in 1906 a large number of inquiries have reached us that have had to be dealt with separately, but in many cases both the inquiry and the answer have been of such an interesting character that public knowledge thereof might be of use to many of our readers. Thus all inquiries of general technical interest will in future be published with their replies, the name of the inquirer either being given or withheld, as he may desire.

We would, therefore, point out that inquiries, which have always been welcome, and which have been dealt with to the best of our ability, will henceforth be especially requested, seeing that they will serve as a useful basis for disseminating knowledge.



THE SAVOY HOTEL EXTENSION.

The alterations at the Savoy Hotel have had considerable attention given to them owing to the rapidity with which the work was done, and the remarkable organisation proved by this rapidity. This was mainly due to the efficient manner in which the steel frame construction was prepared and assembled.

There is no doubt that steel in combination with concrete is very useful for alteration work of this kind, and the particulars given below should be of interest to all concerned in the erection of buildings.—ED.

THE execution of this work involved some intricate problems in construction, and it is chiefly remarkable for the speed with which all these difficulties were overcome, the contract being completed in the record time of eight weeks, although about one hundred thousand pounds was the value of the works executed. This would not have been possible if elaborate preparations had not been made, and the whole of the material prepared and fitted together previous to the actual commencing of the work on the building itself.

Generally speaking, the work included the demolition of the façade and the construction of a new wall some 8 ft. 6 in. nearer to the Embankment, with the removal of the old mansard roof over the entire building, and the heightening of the main walls. In addition to this a new storey was added, 9 ft. high in the clear, and a space was also provided for the various existing pipes under this new floor.

These additions naturally entailed the imposition of certain extra loads on the foundations, and it became necessary to strengthen these to avoid settlement. This work was carried out before the main contract was commenced, as it could not be hurried on account of its nature, and it did not in any way interfere with the business of the hotel.

Upon the commencement of the actual contract, the gantry and scaffolding were erected in five days, and as this scaffolding was about 130 ft. high, with a frontage of 400 ft., it will be seen that no time was lost. The view in *Fig.* 2 gives some idea of the character of the scaffolding work in which over 5,000 cu. ft. of timber and 15 tons of steel were used. Two double passenger lifts for workmen, and four electric hoists for material were erected in place of the usual cranes, and for the erection of the steelwork a track was laid to accommodate a travelling crane which could command the whole building area.

The erection of the steelwork was rendered extremely difficult, owing to the presence of a perfect network of large water pipes on the top of the existing roof, and it was decided that these could not be disturbed on any account.

It was, however, necessary to remove the old roof slopes, and some provision had to be made for supporting the flat portion of the roof on which the pipes were carried. This was overcome by introducing 19 large lattice girders, nearly 5 ft. deep, spanning the distance between the outer walls of the building, about 40 ft., with the diagonal members of each girder so arranged as to clear the pipes, and between which they were threaded. Each of these girders weighed about 6 tons, and they had to be erected at a height of nearly 100 ft. above the ground. They were designed in such a way that they could be dispatched to the site in large sections, with the diagonal members which embraced the pipes separately, and these were hoisted, placed in position, and then jointed up and riveted. These girders, when in position, had the new floor and roof placed on the top of them, and the old flat suspended from the bottom of them, and they thus formed a false floor or pipe chamber. The old flat being left in with the formation of new gutters, a watertight covering is provided below the pipes, and thus any leakage that might occur could not in any way affect the sub-structure.

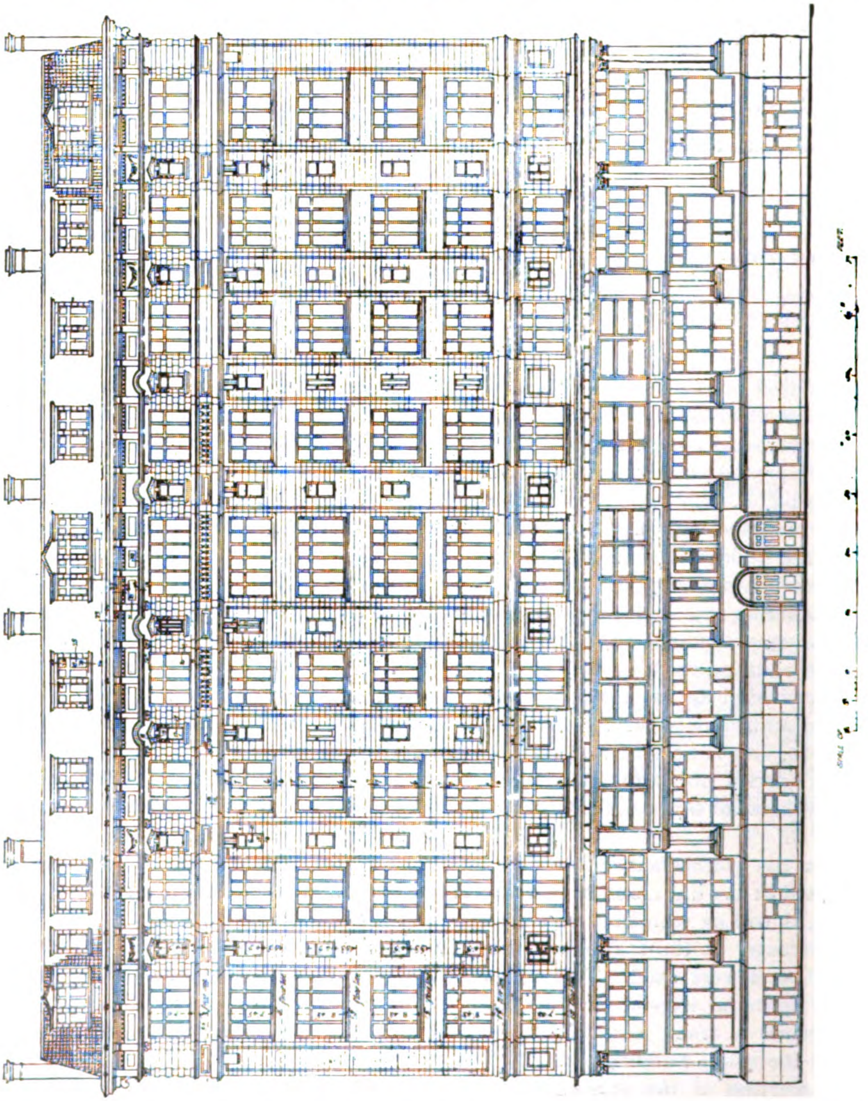


Fig. 1. Elevation of Embankment front.
SAVOY HOTEL EXTENSION.

The method of carrying the new façade, illustrated in *Figs.* 4 and 7, is interesting on account of its originality. The old façade being removed, new girders were introduced at the seventh floor level, consisting of three 12-in. by 6-in. by 54-lb. rolled steel joists, and these support a series of stanchions throughout the length of the building. These stanchions carry one end of the lattice girders, and as they are situated in the position occupied by the old wall, the lattice girders cantilever beyond them to the new wall, and have a projection beyond the stanchions of about 7 ft.

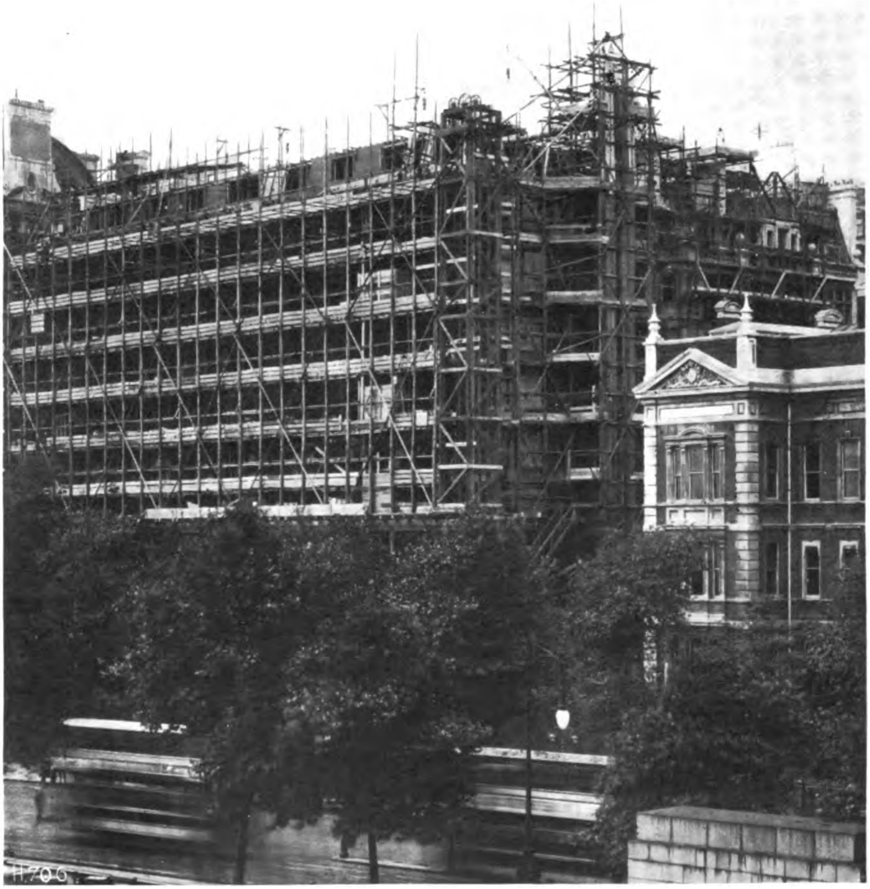


Fig. 2. View of work under construction.
Savoy Hotel Extension

These stanchions are built up of rolled steel joists and steel channels, and as far as possible were kept directly under the lattice girders ; but where this was not possible the weight was transmitted by means of a compound girder, consisting of three 16-in. by 6-in. by 62-lb. steel joists which connected the two adjacent stanchions. Where necessary the stanchions were braced diagonally by small angle irons. From the ends of the projecting lattice girders channel bar hangers were suspended, forming practically inverted stanchions, and these actually carry the whole of the wall con-

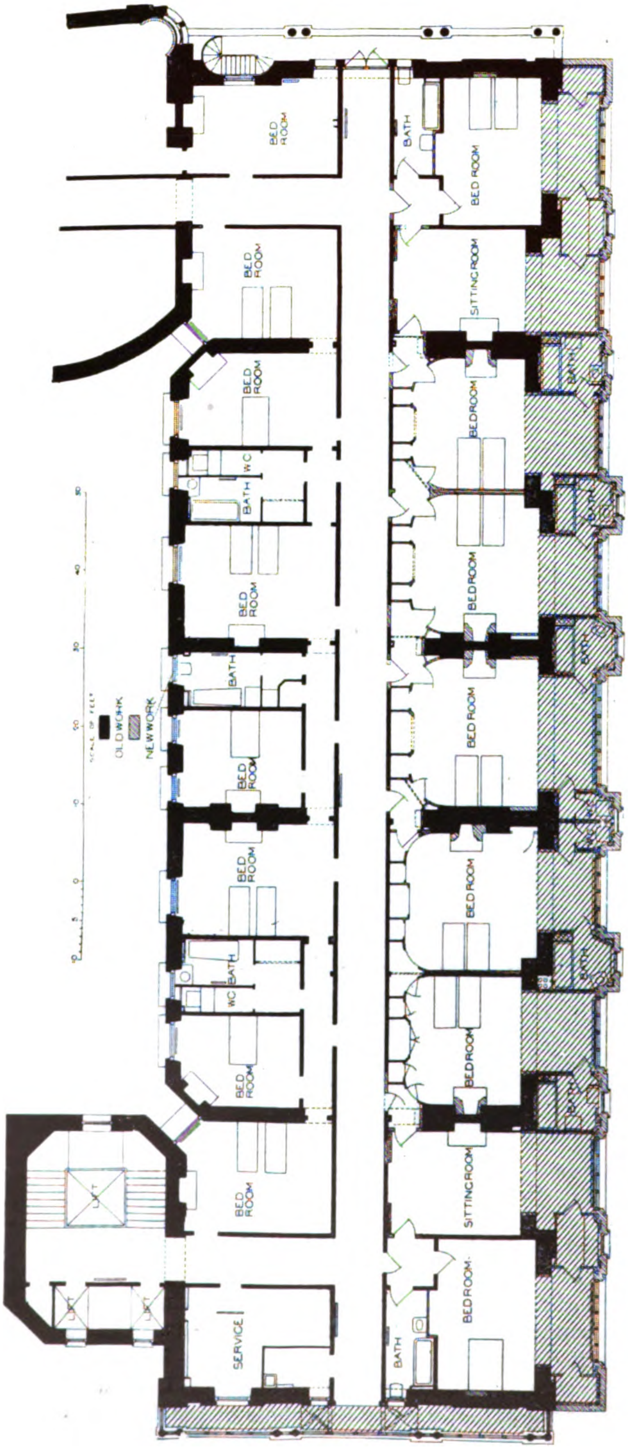


Fig. 3. Plan of sixth floor.
SAVOY HOTEL EXTENSION.

struction from the seventh floor down to the top of the third storey throughout the whole length of the building, the new floor and roof acting as a counterweight to overcome the overturning tendency of the lattice girders. Below the hangers, which extend to the level of the fourth floor, the new wall is carried by steel channel stanchions which extend up from a new girder which was put in at the second floor level, and these hangers and stanchions are connected at their extremities in such a manner that each is capable of taking a portion of the load calculated to come upon the other.

The cross-section of the building (*Fig.* 4) shows the new lattice girders at "A," the position of the stanchions marked "S," and the new girder at the seventh floor level marked "G." The position of the original wall in relation to the new façade is also shown, and the new floor and pipe-chamber can be seen.

Fig. 8 shows a portion of the steel framing for the new sloping roofs and flat, which may be taken as a typical example of the methods employed, while the detail illustrated in *Fig.* 7 shows the end of one large lattice girder where projecting, with the steel hangers

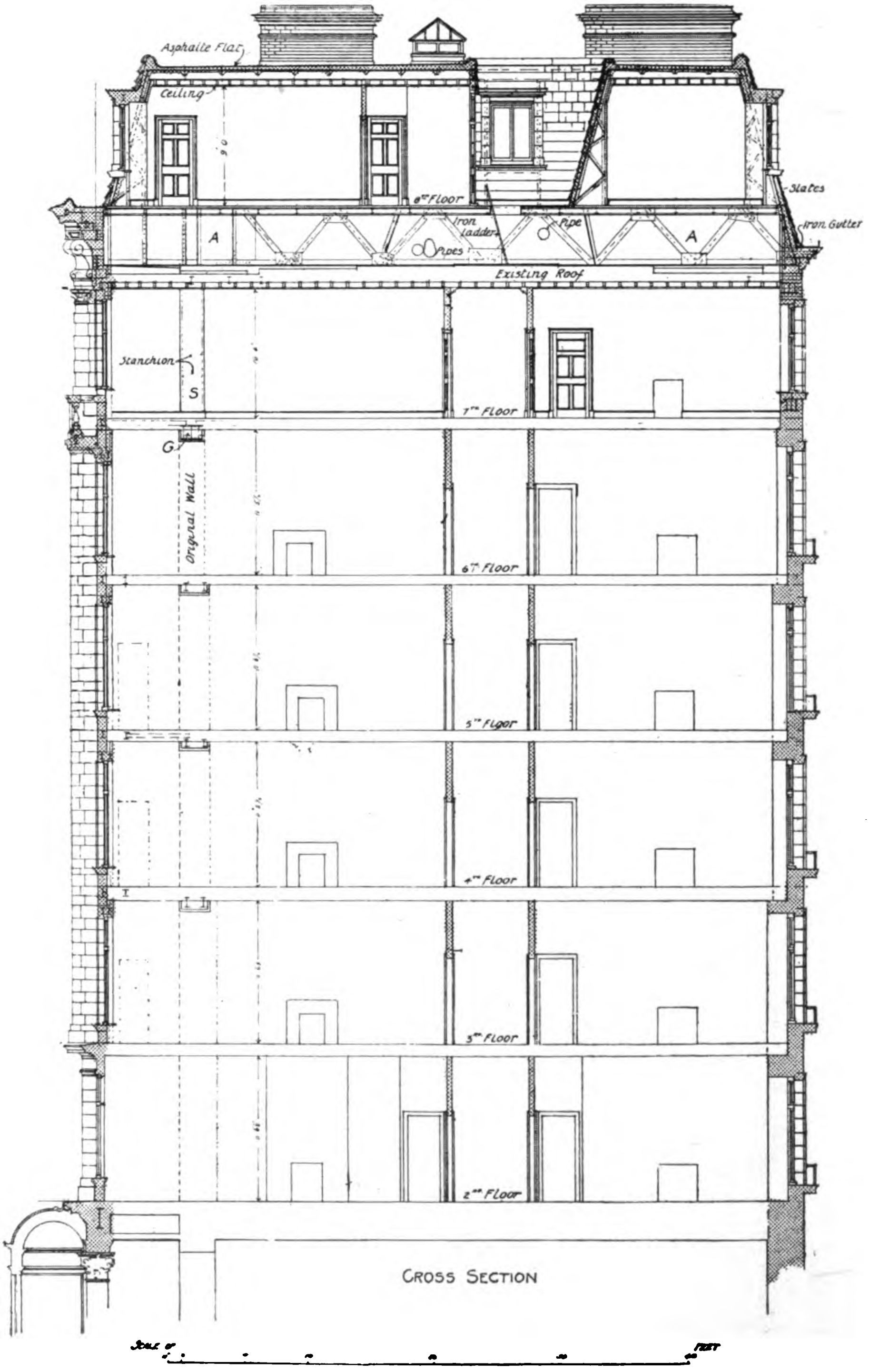


Fig. 4. Cross section showing new floors.
SAVOY HOTEL EXTENSION

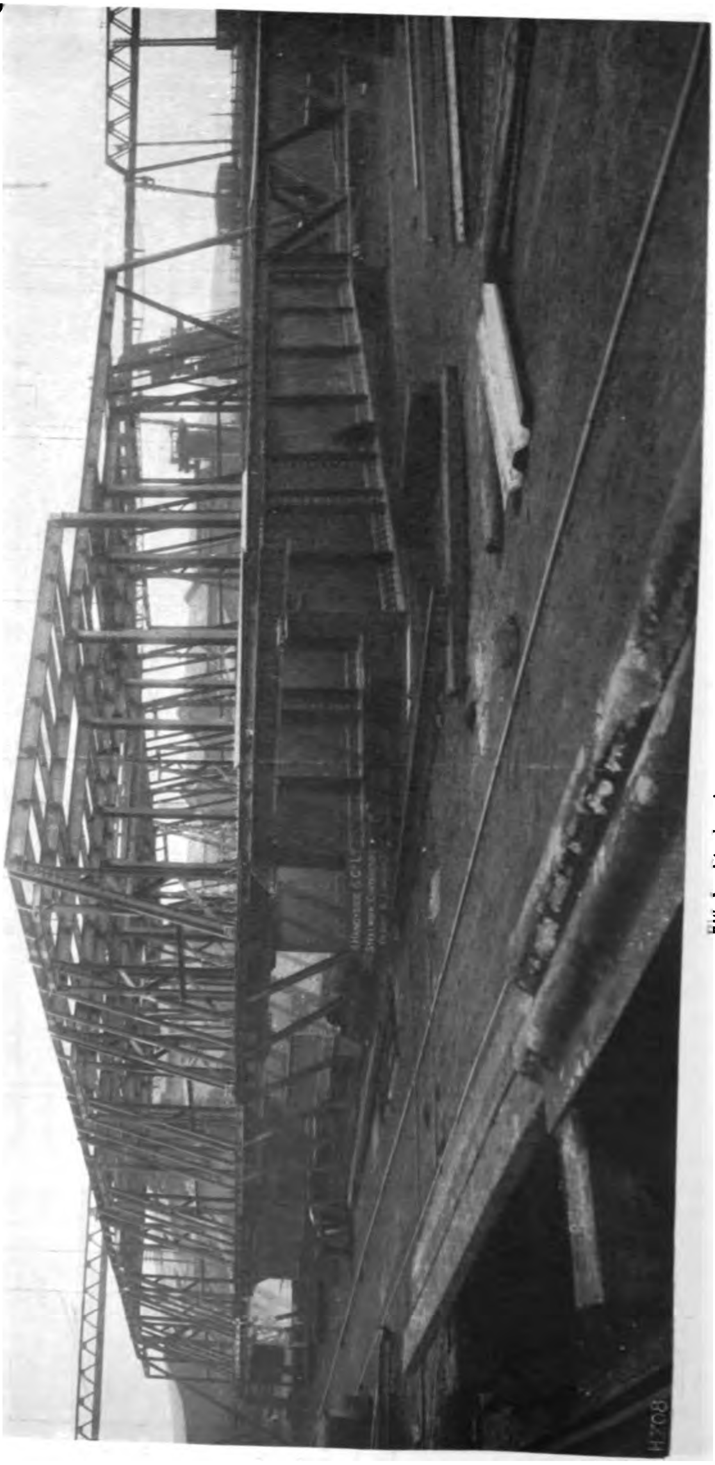


Fig. 5. Steelwork erected in contractors' yard.
SAVOY HOTEL EXTENSION.

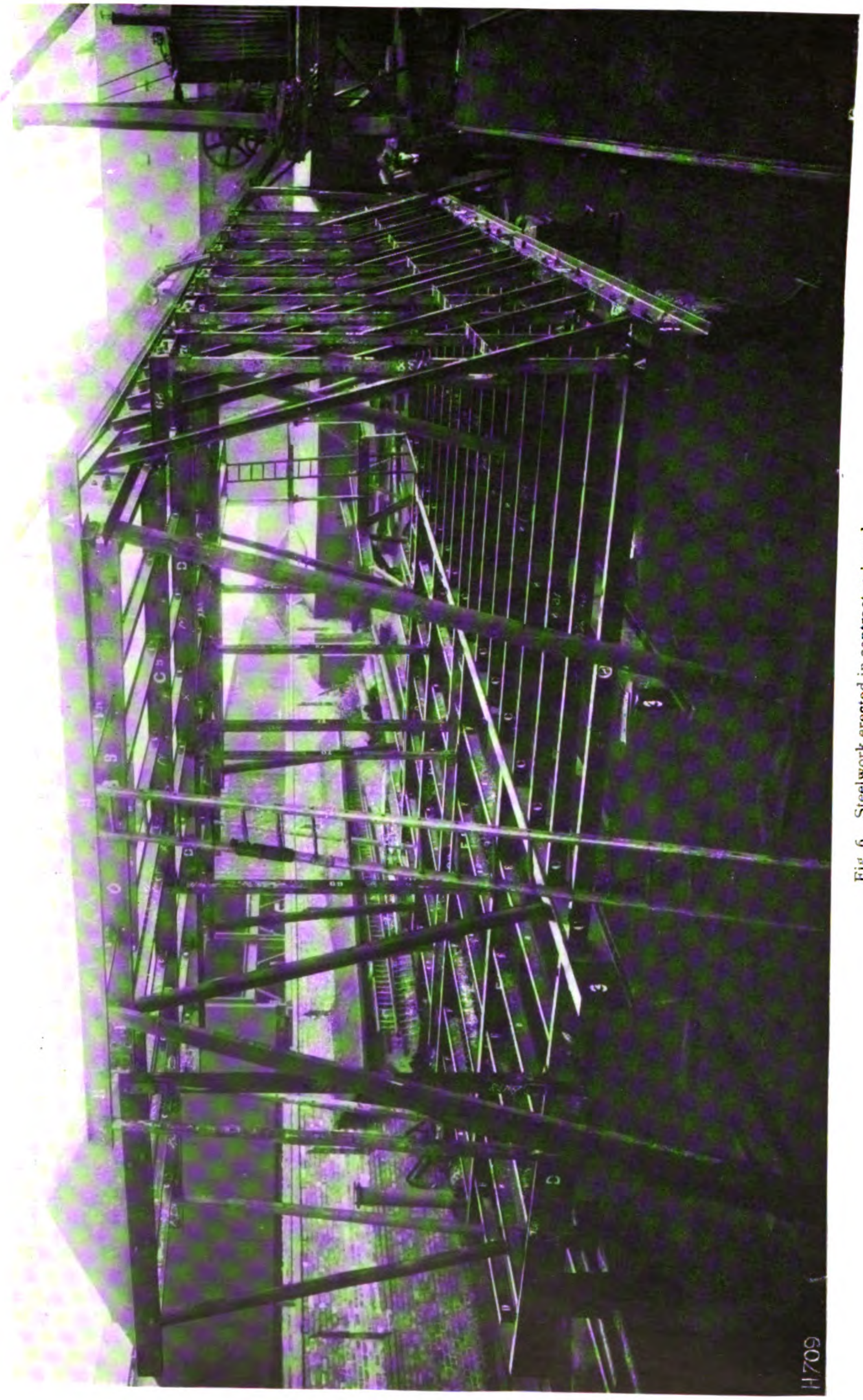


Fig. 6. Steelwork erected in contractors' yard.
SAVOY HOTEL EXTENSION

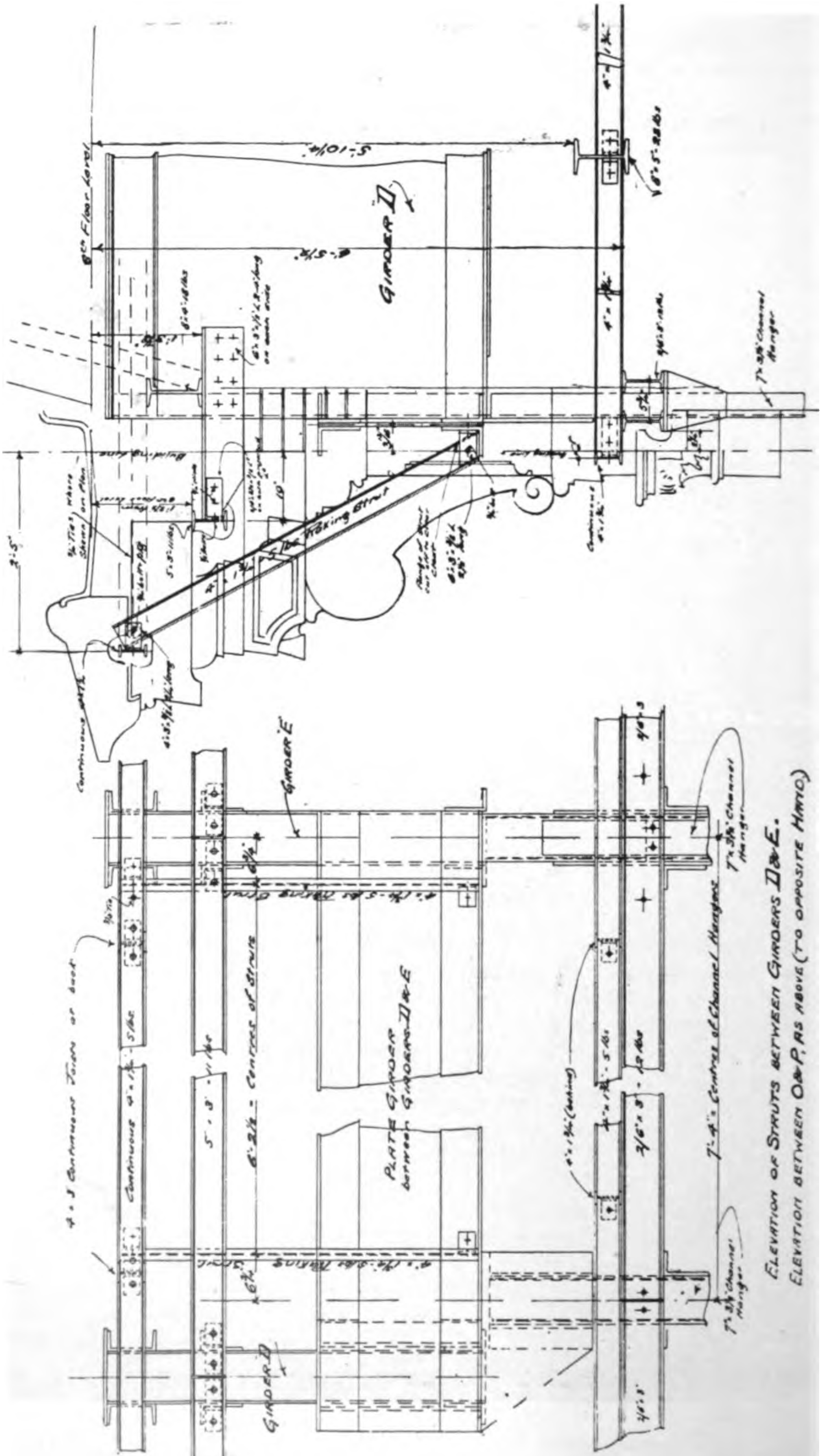

8th Floor Level
5'-10¼"
Girder D
Girder E
Wind Bracing Strut
Plate Girder between Girders D & E
4"x3" Continuous Tiers at back
Continuous 4"x1½"
5'-3"
6'-2¼" = Centres of Struts
7'-4½" Centres of Channel Hangers
7"x3½" Channel Hanger
Elevation of Struts between Girders D & E.
Elevation between O & P, as above (to opposite hand)

Fig. 7. Detail of steelwork.
Savoy Hotel Extension.

attached. The projecting portion of the lattice girder required a solid web to resist the shearing stresses, which were obviously very great compared with those in the remaining portion of the girder. The steelwork in the cornice is also shown in the same diagram.

The new floor and flat roof above were constructed on the steel frame principle, with main steel joists and stanchions, and small filling-in joists varying from 4 in. by 1¾ in. by 6½ lb. to 6 in. by 3 in. by 12 lb. placed at 2 ft. 9 in. to 3 ft. centres. Concrete filling 9 in. thick to the eighth floor and flat, and 8 in. thick to other positions was employed, and this was composed of one part of Portland cement and six parts of clean coke breeze. The method of constructing these concrete floors was ingenious, and enabled a great deal of time to be saved. It was decided that the use of ordinary wood centering would be practically impossible, as the necessary strutting and planking would have to be cut and erected after the steelwork was in position, and this would take some little time; and, again, it would have to remain in position until the concrete was set, and would be in the way, seriously impeding the progress of the other work. In consequence of this, it became necessary to adopt a system which could be prepared before the work was commenced, and which could be speedily erected and allowed to remain in the work. Corrugated iron was selected as the most suitable material, and all the steelwork plans were carefully figured so that the distance between all adjacent girders could be accurately determined, and the corrugated iron was then cut as required for every bay, and prepared and marked complete before being brought to the site. Upon its arrival at the building, each portion was slipped into its position between the joists and allowed to rest on the flanges to form a permanent centre for the concrete, which was then filled in.

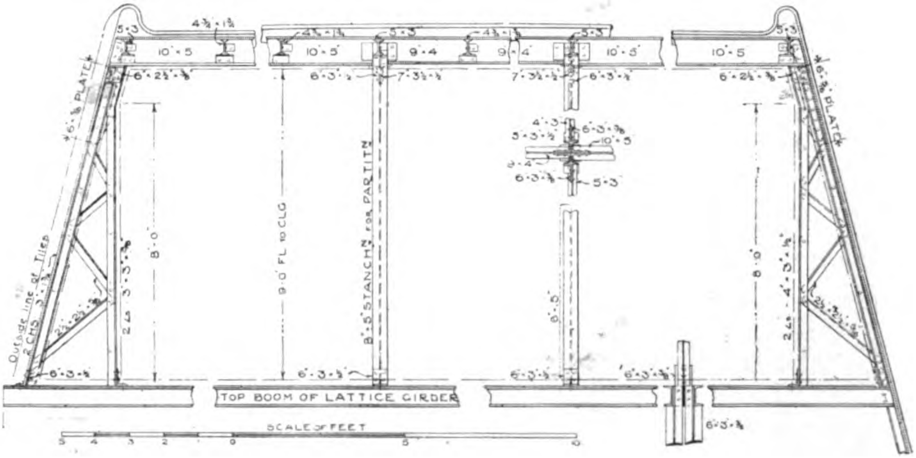


Fig. 8. Steel framing for new roof.
SAVOY HOTEL EXTENSION.

There are about 800 tons of steelwork altogether in the new work, the greater portion of which had to be lifted to a great height, and it was sent to the site in 4,743 separate pieces; while 6,000 rivets and 4,160 bolts were placed in the connections. When it is stated that the whole of this work was completed in twenty days, it will be understood that a most thorough system had to be adopted.

The whole of the work was prepared and temporarily put together in the contractors' works to ensure each portion being correct and complete in every detail.

and a most comprehensive system of marking and colouring was adopted, which ensured every piece being quickly identified and placed in the same position it had occupied when temporarily erected. The illustrations in *Figs.* 5 and 6 show the work as erected in the contractors' works, the marking of the different sections can be seen, and a good general idea of the steel construction obtained. The whole of the internal partitions are constructed with Messrs. Leslie's fireproof interlocking concrete slabs, and over 7,000 yards super of these were used.

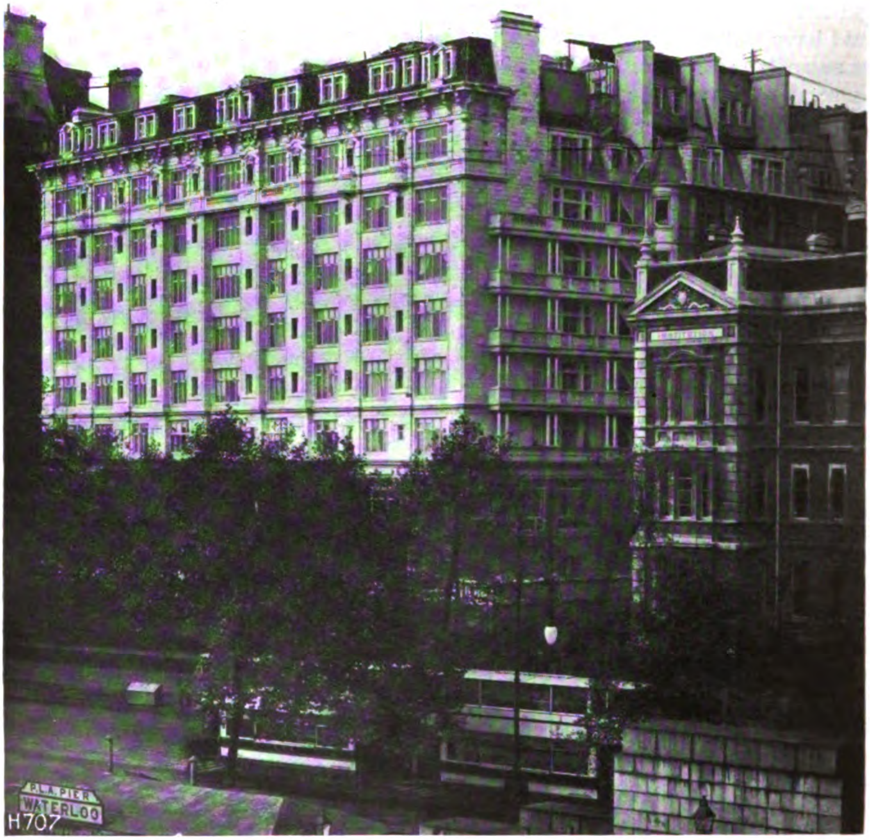


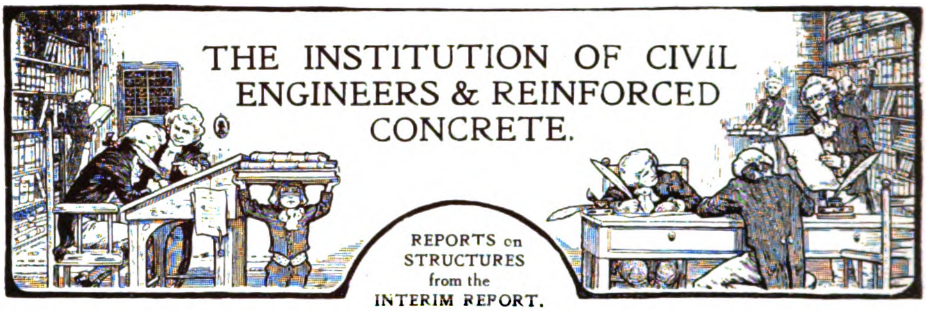
Fig. 9. View of finished work.
Savoy Hotel Extension.

The new façade to the Embankment and the return to Savoy Hill and Carting Lane have been executed in "Carrara ware," and the whole of this work was executed in three weeks. Very careful drawings were prepared, and the material was made, delivered to a vacant site in Kingsway, where it was put together floor by floor, checked to see that all was complete, and then each piece was marked for its position in the building. As soon as the steelwork for the new front was complete, the work of fixing was commenced, the men working from all floor levels simultaneously, and thus the speedy execution was rendered possible.

In addition to all the work described above, the improvements to the hotel have necessitated very considerable alterations to the electric lighting, electric bells, hot and cold water supply, heating, telephones, and lifts. Before the structural alterations were commenced, numerous supply mains on the roof had to be removed and altered, the large cold water storage tanks removed, and temporary tanks fixed and connected up in order to keep supplied that portion of the hotel which was in use the whole time. The work was carried on night and day. The first piece of furniture was removed from rooms preparatory to demolition on August 1st, and on October 3rd the first rooms were occupied by guests after reconstruction. This constitutes a record for British work, and emphasises the value of adopting a thorough system in building methods.

The architects for this work were Messrs. T. E. Collcutt & Stanley Hamp, of Bloomsbury Square, and the general contractors were Messrs. Leslie & Co., Ltd., of Kensington Square, whose thorough organisation made the success of the work possible in the limited time. The sub-contractors for the steelwork were Messrs. Handyside & Co., Ltd., of Derby.

THE INSTITUTION OF CIVIL ENGINEERS & REINFORCED CONCRETE.



REPORTS on
STRUCTURES
from the
INTERIM REPORT.

The Preliminary and Interim Report of the Committee on Reinforced Concrete appointed by the Institution of Civil Engineers, which has formed the subject of critical reviews in our issues for October and last month, contains a number of reports on structures of reinforced concrete which have been in service for some years, and such original data form the chief value of the report. We here reproduce abstracts therefrom, printing, however, one report in full to show the general standard form in which the reports are presented, this full reproduction being that on the bridge at Wilmersdorf on page 884.—ED.

AUSTRIA-HUNGARY.

SWIMMING SCHOOL BRIDGE AT STEYR, AUSTRIA-HUNGARY.

Report by KARL NAEHR, *Civil Engineer.*

(*Translated and Abstracted by* G. R. Redgrave, *Assoc.Inst.C.E.*)

General Description. — The characteristic feature of the design is that the iron used by way of reinforcement constitutes a self-supporting rigid truss. The span is 138 ft., the width of the bridge is 19·7 ft., and at a temperature of 15° C. the rise of the arch is only 8·58 ft., which may be regarded as extremely small in the case of a concrete arch of this character. Though in the first instance there were serious settlements, no injuries of any kind can now be detected. No details of cost are given.

Age of the Work.—11 years. The abutments were completed in March, 1898, and the concrete work was finished on May 7th, 1898.

External Influences. — Exposed to the ordinary conditions of heavy road traffic, but to no special injuries by smoke, gases, electric currents, or more than the usual changes of temperature, the range being from $-20°$ C. to $+25°$ C.

General Condition of the Work at the Present Time.—The bridge proved on investigation to be in perfect repair, and with the exception of the slight flaking off or superficial detachment of scales, usual in all concrete structures, there were no injuries such as cracks or fissures to be detected.

General Features of the Design.—The extremely small height available for the rise of the arch seemed to necessitate its execution as a three-hinged arch, so as to counteract as far as possible any shifting of the abutments, as also the effects of changes of temperature.

Loading Tests of Finished Work and Failures or Deterioration.—The striking of the wedges of the scaffolding may be regarded as a preliminary test, and this took place 17 days after the concreting was finished. A sinkage at the crown of the arch of 3·93 in. was caused thereby, and this includes the subsidence during the concreting, amounting to 1·96 in. This somewhat considerable deflection was increased by 1·18 in. more, when 3 days later the external facing walls and the greater part of the earth filling were added. It was not possible at this time to observe any movement in the abutments.

This deflection was regarded as excessive, and it was considered that the descent due to the elasticity of the concrete arch ought not to have exceeded 2·75 in. It was accounted for in various ways, but probably, while the asbestos packing at the back of the hinges was in fault, the main cause of the mischief was the shifting of the solid mass of the abutments. By way of precaution the wedges were again driven up to support the arch and to afford a longer setting time for the concrete.

After a second interval of 17 days, the wedges were again drawn and the scaffolding was removed. The arch at once sank 1·96 in. below the level at which it stood when supported, and this sinkage slowly increased during the next 10 days to 3·14 in., whereupon, without any cracks or signs of injury the arch finally came to rest. In consequence of the river being flooded, it was unfortunately not possible to measure accurately the spread of the abutments.

The gradual cessation of the sinking has been attributed to the slow consolidation of the soil behind the back face of the abutments, which in time rendered the earthwork capable of resisting the thrust of the arch, as exerted on the abutment. It was estimated that the maximum amount of this earth pressure must have reached 711 lbs. per sq. ft. Although good solid ground ought to take this amount of thrust, it was considered that owing to the withdrawal of the poling plates in the trenches for the concrete the soil had been loosened.

After an interval of 3 weeks from the time the arch came to rest, when no further movements were perceptible in the structure, except those due to changes of temperature, the regular loading test was carried out.

First the roadway of the bridge was weighted with pig iron and granite sets to the extent of 116 tons, equivalent to a distributed load of 94 lbs. per sq. ft. One hour after this load was applied the subsidence at the crown was 1·53 in. On removing the load on one half of the area of the bridge, the depression on the loaded half was increased, at the centre of this half, by 0·59 in., while the centre of the unloaded half rose 0·59 in. When the whole load was taken off the structure the sinkage at the crown was decreased by 0·67 in., and the permanent deflection caused by the loading test thus amounted to 0·86 in., which was not regarded by experts as an injurious permanent deformation, but was thought to be caused by a further movement in the abutments of about $\frac{1}{10}$ in. Permission was accordingly granted for the use of the bridge.

The contractors, however, were not satisfied with this decision. They stripped off the entire filling above the concreting of the arch, and replaced the cement rendering over the concrete by a coating of asphalt ¾ in. thick. They likewise deemed it prudent to provide a better resistance behind the concrete abutments, and with this object in view they drove a stout iron tube, 2·36 in. in diameter, with a massive steel point, to a depth of 15 ft., so as to make a series of holes about 27 in. apart, to the number of 37 in all, on each side of the bridge, spreading out into a fan-shape behind the mass of concrete. Into these holes, by means of the gradual withdrawal of the tube, cement grout was driven into the surrounding soil by the aid of a force pump. In this way the whole of the material behind the abutments was converted into a solid block of concrete, and its resistance capacity was greatly increased.

At the present time no further signs of the subsidence of the arch are apparent, and the settlement, which at first seemed so formidable, has been entirely averted.

PILE FOUNDATIONS FOR THE WORKS OF THE VIENNA-DANUBE SAND DREDGING COMPANY.

Report by KARL NAEHR, Civil Engineer.

(Translated and Abstracted by G. R. Redgrave, Assoc.Inst.C.E.)

General Description.—The works in question constitute the foundation for an erection of iron columns and a platform supporting a dredging apparatus and sand-sifting plant. The structure, which is carried on reinforced concrete piles, has thus to support great and concentrated loads. The reason for the employment of piling was that the erection occupied made ground, which was filled in at the time of the carrying out of the Danube Regulation Works at Vienna. In spite of the fact that this filling took place some considerable time ago, it was deemed expedient by the contractors to go down to the solid gravel bed, at a depth of about 16 ft., and under these circumstances the use of piling appeared to be indicated. No details of cost are given.

Age of the Work.—Completed early in 1909.

External Influences.—Piling wholly embedded in loose soil.

General Condition of the Work at the Present Time.—Although the work was executed during frosty weather, and with frozen materials, no defects have shown themselves.

General Features of the Design.—The carrying out of the design involves two entirely distinct operations—namely, first, a drilling or perforating process, followed by the second, consisting of a ramming or stamping process.

In the first place an iron tube, whose diameter is determined in accordance with the requisite strength to support the necessary load, is driven down by the ordinary boring process to the depth needed, with the simultaneous removal of the core. When this part of the work is finished, concrete is passed down the tube and is energetically rammed, while at the same time the tube is raised gradually. By this means the concrete is driven out of the bottom of the tube and is caused to pass over the outer edge of the tube into the surrounding soil, and this latter, owing to the continual stamping and ramming, is compressed in the best possible way. As soon as one layer of concrete has been forced down to the utmost extent the tube is slightly raised and more concrete is added and again rammed, and this is repeated until the whole perforation made by the tube is occupied by a concrete pile, when the iron tube, wholly withdrawn, reaches the surface.

After completion the heads of the various groups of piles were united together by means of massive slabs of reinforced concrete, so as to ensure, as far as possible, an equal distribution of the load over the whole of the piling.

In the determination of the dimensions of the piles or the diameter of the tube (11·8 in.) it was assumed, in accordance with previous experiments, that for each sq. in. of surface the frictional resistance would be 14·19 lbs., and no allowance was made for the fact that these piles rested on firm ground or for the advantage likely to be derived from the varying diameters. If, therefore, each pile is loaded to the extent of about 24½ tons, and only the skin friction due to the average diameter is taken into account, it would seem that there is a double factor of safety to guard against eventual settlements.

Failures or Deterioration.—As the whole of the work was executed during the prevalence of a sharp frost, not only the water, but also the sand, had to be heated, and at times about 1½ per cent. of table salt was added to the mixture. Notwithstanding these adverse conditions the work has stood well, and after use for nine months showed no sign of injury.

FRANCE.

WHARFING AT CHANTENAY, PORT OF NANTES.

Report by Eugène Mugniot, Ingénieur des Ponts et Chaussées.

(Translated and Abstracted by G. R. Redgrave, Assoc.Inst.C.E.)

General Description.—Riverside wharves, consisting of a decking of reinforced concrete, partly supported on concrete piles driven down into the bed of the river and partly on a rear retaining wall holding up the river bank at the back of the pier, this wall being also constructed in reinforced concrete. The only injuries sustained by this work are from the effects of a collision, which has laid bare the reinforcement in one of the piles: reference is also made to a slight settlement in the concrete screen wall.

No particulars as to cost are available.

Age.—Eight years.

External Influences.—Nothing of importance to be noted.

General Condition.—The work is in good condition, and nothing appears to threaten its preservation. There may be noticed, however, a slight settlement of the reinforced concrete screen wall, supporting the earthwork filling at the back, while on one of the outer concrete piles there are traces of what was an apparently violent collision, which has laid bare the reinforcement at the level of low water of spring tides.

Failures or Deterioration.—A slight settlement of the reinforced concrete screen wall supporting the earthwork at the back. This appears to have been due to voids caused by the escape of the sand forming the filling of the embankment behind the screen of sheet piling. It occurred several years ago, but it has since made no progress, and therefore causes no further anxiety. It would have been preferable, however, to avoid it, either by preventing the movement of the sand or by stiffening the wall in question by ribs or buttresses.

TWO RESERVOIRS AT CHÂTILLON-SOUS-BAGNEUX.

Report by Eugène Mugniot, Ingénieur des Ponts et Chaussées.

(Translated and Abstracted by G. R. Redgrave, Assoc.Inst.C.E.)

General Description.—These covered reservoirs are identical in point of design, and they are wholly sunk beneath the surface of the ground. One was completed 13 years and the other 12 years ago. They are circular in plan, 105 ft. in diameter, with a height of 17·2 ft. The outer walls vary in thickness from 3·93 in. at the top to 6·69 in. at the base, and they are reinforced with vertical and horizontal rods. They rest on a concrete base, and are covered with an arched, flattened dome in the centre, 26·24 ft. in diameter, and carried on 12 octagonal piers spaced at equal distances apart. The dome is surrounded by two rings of wagon-head vaulting, each 19·68 ft. wide, resting on the outer wall on a row of 24 octagonal piers and on the inner row of 12 piers already mentioned. The concrete of the arched vaults forming the covering is in all cases 4·72 in. in thickness, and this is wholly earthed over. The work was entrusted by the Compagnie Générale to a contractor, who made his own calculations and had great freedom of action allowed to him.

No estimates of cost are given.

Age of the Work.—(*a*) 13 years; (*b*) 12 years.

External Influences.—The works are entirely sunk beneath the surface of the ground. The water of the Seine, which the reservoirs contain, does not greatly vary in temperature. It is always above 0° C. and below 24° C. As they are mostly kept full, the range of temperature will accord with that of the Seine water. No chemical action of any kind has been observed, and the structure is not exposed to any vibrations.

General Condition. — The work has never required any important repairs. The interior is replastered or coated with fresh cement stucco at long intervals. A few years ago cement grout was successfully run into some fissures, but there have been no leakages of any magnitude.

The present condition of the work is excellent.

General Features of Design.—Owing to the fact that great latitude was allowed by the water company to the contractor no detailed designs were prepared, and no calculations are extant. It appears that no allowance was made for the longitudinal slip of the concrete or for the adhesion of the concrete to the reinforcement. It may be assumed that the work was undertaken without any precise calculations.

UNITED STATES.

BRIDGE NEAR MECHANICVILLE, N.Y.

Report by GEORGE PERRINE.

(Abstracted by E. W. Hollingworth, M.A., Assoc.M.Inst.,C.E.)

General Description.—The bridge, which is 17 ft. wide, is composed partly of steel girder spans and partly of concrete arches. The latter, three in number, have spans of 100 ft., 100 ft., and 55 ft. respectively between centres of piers, and carry a single track overhead trolley line of the Hudson Valley Railway Co. over a shallow stream called Anthony Kill. The arches are reinforced with five ribs of 7-in. " girder " rails continuous over each span. The other portions of the structure are not reinforced.

An article on the work appeared in the *Engineering News* of November 5th, 1903[1].

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[1] *Engineering News*, vol. i., p. 408. From this article it appears that the line is a tramway, that the bridge was built early in 1902, and that old " street railway " rails were used for the reinforcement.

Age.—The bridge was built during the winter of 1902.

External Influences.—The work was exposed to frost during construction, some of the concrete being placed when the temperature was 20° F. It is subjected during the year to temperatures varying from about 110° F. to —20° F., to the vibrations caused by the 50-ton cars, and possibly to the action of electric currents.

General Condition.—The general condition of the structure is good, but there are vertical cracks in the spandrel walls near the haunches and other cracks run along the extrados for nearly the whole length of every arch. The east spandrel wall of the south span has been forced outwards about ½ in. The stucco facing has scaled off in places.

General Features of the Design. — The arches, which are of concrete, are segmental, and have a rise of nearly one-fifth of the span. The thickness at the crown and springing is 3 ft. and 4 ft. respectively in the 100-ft. spans, and 2 ft. and 3 ft. respectively in the 55-ft. span. The reinforcement consists of five 7-in. "girder" rails bent to conform to the shape of the arches, spliced by means of fish-plates, and extending over the entire length of each arch. They were laid with 6 in. of concrete beneath them. The piers, which have a width of 10 ft., are not reinforced, and rest upon slate rock, which was in no case more than 12 ft. below the surface of the ground. No expansion joints were provided.

Failures or Deterioration.

(*a*) *Design and* (*c*) *External Influences.*—The cracks, which have been formed in the unreinforced spandrel walls, are attributed by the Reporter to the omission of expansion joints in the structure, which is exposed to a range of temperature of about 130° F.

GERMANY.

HIGH-LEVEL RESERVOIR FOR THE PYRMONT WATERWORKS, GERMANY.

Report by ROBERT OTZEN, Professor at the Hanover Technical High School.

(Translated and Abstracted by G. R. Redgrave, Assoc.Inst.C.E.)

General Description.—There are two dome-shaped chambers, each 24·27 ft. in diameter, with a clear height to crown of 12·13 ft., and a height to level of water-filling of 9·84 ft. The mean thickness of concrete is 4·72 in. The two chambers are separated by a shaft, measuring about 8·2 ft. by 6·56 ft., and carried to a depth of some 3 ft. below the bottom of the reservoir. The work was constructed by a special contractor. The reservoir is placed on rock foundations, and is entirely embedded in the soil to an average depth of 39·37 in. It has always been absolutely water-tight, and the present condition is perfect. No details are given as to the cost.

Age of the Work.—Constructed during the year 1895.

External Influences.—As the reservoirs are placed on a solid rock foundation, and are entirely beneath the soil, they are exposed to no injurious atmospheric or other influences. They are not subject to frost, and as the concrete was mixed during mild, damp weather it became well set.

Condition of the Work at the Present Time.—An opportunity was afforded in December, 1909, when both of the chambers had been emptied, to examine their condition, which was found to be perfect. According to the statement of the authorities no repairs have been needed during the 14 years that the reservoirs have been in use, and they have remained water-tight from the outset.

THREE-HINGED ARCH BRIDGE IN REINFORCED CONCRETE OVER THE PRINZE-REGENTEN-STRASSE AT WILMERSDORF.

Report by ROBERT OTZEN, Professor at the Hanover Technical High School.

(Translated and Abstracted by G. R. Redgrave, Assoc.Inst.C.E.)

General Description.—The scheme comprised the exterior widening of two existing brick-arch bridges and the filling in of the intervening space between them, 19·68 ft. in width, by means of arches in reinforced concrete. The new work was kept entirely distinct from the old, to provide against settlement, and was separated by layers of millboard-felt. Owing to the flatness of the arch (rise 1 to 12), the three-hinged system of construction was adopted. The contractors provided the designs. The finished bridge carries a very heavy railway traffic, and the vibration is intensified by the very limited amount of earth-filling above the crown of the arch. Notwithstanding these drawbacks the work has stood well and the present condition is said to be satisfactory. No details of cost are given.

I. Age of the Work.—Executed during the summer of 1907.

II. External Influences.—In order to provide the requisite headway under the bridge the thickness at the crown had to be reduced to a minimum, and the heavy railway traffic exposed the structure to severe vibration. The extreme flatness of the arch, which has a rise of only about one-twelfth of the span, is also unfavourable to the durability of the structure, because it prevents the upper layers of the filling at the haunches, when saturated with rainfall, from being readily drained. It is pointed out that the somewhat extravagant proportions selected for the work, more especially in respect to the ironwork, will be of advantage in these circumstances, because by this means the parts exposed to vibration will not be unduly stressed.

III. Condition of the Work at the Present Time.—The present condition of the structure is satisfactory. There are no fissures in those parts bearing the weight. Care was taken to make the joints of ample width in those places where settlements were liable to occur, as for example at the union of the face-wall with the abutments above the hinge-joints at the springings, and no attempts were made to mask these lines by cement-stopping.

IV. General Features of the Design.—The bridge was built from designs made by the contractors, the ironwork used for reinforcement forming a self-supporting truss.

(*a*) METHODS OF CALCULATION.—The ratio of the modulus of elasticity of the iron to that of the concrete was assumed to be 10. In the first instance approximate calculations were made in the case of seven selected cross-sections, in accordance with formulas given in the report, and as the outcome of these static investigations, and a full and more careful examination of the section that appeared to be most severely stressed, neglecting in this latter calculation the concrete, the following stresses were deduced :

(*b*) STRESSES :

	Lb. per sq. in.
Concrete in compression	647
Concrete in tension ... ... (Without regard to resistance.)	109
Iron in tension	1,080
Iron in compression	6,157
Shearing stress	64
Adhesion of iron to concrete	64

V. Materials.

(*a*) COMPOSITION OF CONCRETE.—The concrete was composed of Portland cement of the "Pferd" brand from Hanover, sharp gravel sand from Trebbin, and excellent broken stone consisting of porphyry from Gimritz. It was mixed in the following proportions :

Abutments	Bottom	1 : 6 : 6
	Centre	1 : 5 : 5
	Upper part	1 : 3 : 3
Arches		1 : 2½ : 2½
Face-wall		1 : 5 : 5

(*c*) QUALITY OF REINFORCING BARS.—The reinforcement consisted of ordinary commercial wrought iron.

(*e*) TESTS OF CONCRETE.—Small cubes of concrete were tested in accordance with officia regulations by the Testing-Office at Lichterfelde, and gave the following results :

Proportion.	Age.	Strength in Compression.
1 : 6 : 6 ...	76 days ...	1,948 lb. per sq. in.
1 : 5 : 5 ...	132 " ...	1,635 " "
1 : 3 : 3 ...	69 " ...	3,199 " "
1 : 2½ : 2½ ...	64 " ...	3,512 " "

The concrete in the case of the last-named mixture gave a tensile strength of 711 lb. per sq. in.

VI. Methods of Construction.

(*a*) MIXING THE CONCRETE.—The concrete was prepared in a mixing machine which measured the ingredients automatically. The amount of water used was, as is customary, about 10 per cent. The concrete filling for each arch was carried on without interruption, working day and night, and the time occupied in completing each arch varied from 36 to 40 hours. The new work was separated from the old by interposed sheets of millboard felt.

(*b*) PRECAUTIONS USED IN PLACING REINFORCING BARS.—No special precautions were necessary in the insertion of the iron reinforcement, as from the character of the construction no displacement was to be apprehended during the process of ramming in the concrete. It is hardly needful to say that the stamping in of the material had to be conducted with great care in the vicinity of the hinges, owing to the comparatively small size of the meshes in the ironwork.

Special precautions were necessary in the arrangement of the reinforcement at the places where the concrete work joined the hinges at the springing and at the crown of the arch. The cross-hooping is made much stronger at these parts, and the main longitudinal bars are united direct to the outer surfaces of the hinge-blocks. The reinforcements needed to take up the shearing stress are interlaced around the upper and under longitudinal bars in lattice fashion—a method of construction which lends itself well for the framing of the armouring. Special joints are made in the customary way with hooks. The hinges differ in no way from those commonly employed in iron bridge building. They are formed of cast-iron, while the hinge-bolts are made of the best steel. Details are given of the hinges and of the method of uniting the reinforcement to the hinge-blocks. The total span amounts to 80·04 ft., and the width of centre bridge is 19·68 ft. The rise of the arch from the springing level is 6·75 ft.

(*c*) TIME ALLOWED BEFORE THE REMOVAL OF CENTERINGS.—The arches, after the concreting had been completed, were kept supported by the centering for a period of 5 weeks before the shuttering was removed. All through this time the weather conditions were satisfactory, and there were no frosts while the work was in progress.

VII. Loading Tests and Deflection.—After the completion of the concreting and the filling-in of the arch, some amount of sinkage of the central hinge was to be expected. The sinkage due only to compression in the concrete is calculated to be 0·4 in. To this must be added approximately:

	Inches.
Cross-strains, etc.	0·23
Alterations of temperature	0·63
Contraction of the concrete during drying	1·41
Spreading of the abutments in consequence of the compression of the surrounding soil	1·57
Effect of settlement in the centering due to loading	1·57
Add original amount, as above	0·40
Total	5·81

Provision was made for these anticipated settlements by increased height in the centering. On the completion of the work after the centering was struck the actual settlements amounted to in

	Inches.
Arch I.	Nil
„ II.	0·35
„ III.	0·15

After the bridge had been in actual use for three or four months careful measurements of the further deflections were again made with the following results:

	Inches.
Arch I.	0·19
„ II.	0·31
„ III.	0·31

As these settlements may easily be explained as arising from compression due to regular working, further measurements were not considered necessary and accordingly were not taken.

VIII. Failures and Deterioration.—The movements which must unavoidably occur in a three-hinged arch of so slight a rise as in the present case would inevitably destroy the stucco work over the joints purposely left to allow for settlements, or if the width provided for this purpose happens to be insufficient, small hard particles of stone are liable to become wedged in the joint and thus to cause flakes of the concrete walling to be detached. A few slight defects of this character are manifest, which must be ascribed to one or the other of these causes. In that part of the work which occupies the space between the two brick arches, it was not necessary to attend to the external appearance, and wide joints were provided at these places. It is here that the structure is in the best condition. On the south side widening, the architectural embellishments of the façade, which were carried out by the stonemason in the concrete itself, are in a perfect state of preservation, but in those on the north side there are slight traces of weathering and decay, most likely due to errors in the mode of executing the work. In the northern arch traces of damp are visible on the face-wall, which can only be explained by assuming that defects in the covering over the top of the arch have allowed water to percolate and that this has then worked its way into the face-walling.

It is needless to state that extreme care is required in the case of arches so flat as this is, in order to prevent the water from soaking through.

ITALY.

WATER TOWERS AT PIOMBINO.

Report by ING. CORLO PARVOPASSU.

(Translated and Abstracted by G. R. Redgrave, Assoc.Inst.C.E.)

General Description.—These water towers of reinforced concrete have lately been erected on the sea coast at Piombino, by the Blast Furnace and Foundry Co., to serve for the storage of 330,000 gals. of sea water for use in their works. The two cylindrical reservoirs are each 32·15 ft. in diameter and 36·09 ft. in depth, mounted on an open-work base formed of concrete piers, with horizontal- and cross-bracing, the height of each of which is 57·41 ft. above the level of the foundations, or 49·21 ft. above the ground line. They were completed in February, 1908, from designs furnished by Mr. Italo Chieri, of the firm of C. Gabellini & Co., of Rome, the contractors for the undertaking. After preliminary trial it was deemed advisable to strengthen the supports by additional rods and cross-ties. No leakages of any importance have taken place, and the reservoirs are in good condition. The first cost of £3,200 was increased by the subsequent work to a total of £4,400.

Age of the Work.—Two years. The towers were in course of erection from July, 1907, to February, 1908, but after the initial tests were carried out it was thought necessary to strengthen the bases, and the final tests took place in January, 1909.

External Influences.—No extreme ranges of temperature were encountered during construction. The reservoirs stood empty for several months after completion, and were exposed to a hurricane of extreme violence in October, 1908.

General Condition of the Work at the Present Time.—Though when they were first filled there were traces of percolation for a height of about 6·56 ft of the drums, there were no signs of leakage at the time of the trial of the work. The Reporter found in the case of one of the reservoirs some patches of moisture near the bottom when examined in February last, but the escape was very slight and capable of ready repair. This was probably caused by changes in temperature, which gave rise to irregular deformation of the structure, as also to the imperfect condition of the coating of tar applied to the inner surface in order to protect the cement rendering from the possible attack of the sulphur generated by the stagnant sea water.

BRIDGE ACROSS THE RIVER BORNIDA, NEAR MILLESIMO, ITALY.

Report by ING. CARLO PARVOPASSU.

(Translated and Abstracted by G. R. Redgrave, Assoc.Inst.C.E.)

General Description.—This structure is situated about 2½ miles distant from Millesimo, on the main road from that town to Murialdo, in the Province of Genoa.

It was erected in 1902 to take the place of a masonry bridge of three arches, built in 1894, and destroyed by a flood in 1900. The bridge consists of a single span of 167·32 ft., the extreme width is 19 ft., width of main concrete arch 17·38 ft., and the rise of the arch is 16·73 ft. The abutments in masonry of the former bridge were utilised. The level concrete decking is carried by forty-eight slender piers, rising from the extrados of the arch. The concrete work was executed with great rapidity, and was completed on August 9th, 1902. With the exception of some trifling and harmless fissures the condition of the bridge is perfect. The cost, exclusive of the abutments and approaches, was £2,000; the additional value of the old work may be estimated at £1,200.

Age of the Work.—Eight years. The concrete arch was built in 1902 on masonry abutments erected in 1894.

External Influences.—The structure is exposed to no exceptional weather conditions, nor has it to undergo any excessive loading.

General Condition of the Work at the Present Time.—The bridge has remained from the outset wholly free from defects, and no repairs have been needed. In view of this fact the provincial authorities have since caused two similar bridges to be erected, the one with a span of 164 ft., and the other having a span of 137·79 ft., both being carried out by the same company. There are a few unimportant fissures at the haunches, and where the decking and parapet join the old work. These can readily be accounted for by the slight and inevitable settlement due to the great weight of the main arch.

BELGIUM.

VIADUCTS AT MERXEM, NEAR ANTWERP.

Report by J. W. BROUGH, Assoc.M.Inst.C.E.

General Description.—The work consists of a small bridge of 33 ft. span, constructed of straight reinforced concrete beams, and a large bridge, 577 ft. long and 40 ft. wide, of the arched-rib, open spandrel type, with three central spans of 144 ft. 4 in. between centres of piers, and two side spans of 72 ft. 2 in., the latter being semi-arches or cantilevers. The spandrels adjoining the end piers are braced, while those adjoining the centre piers are unbraced.

A description of the work by Messrs. P. de Heem & C. de Maesschalck appeared in *Annales des Travaux Publics de Belgique*, February, 1907[1].

Age.—The bridge was finished in January, 1907.

External Influences.—The range of temperature is normal, and no special apparatus or hinged joint was provided to allow free expansion. The bridge carries an electric tramway and a narrow-gauge railway in addition to ordinary road traffic.

General Condition.—The structure appears to be in a perfect state of repair. No cracks or other injuries are visible.

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[1] A reprint of this article, with photographs of the bridge, was published in *Le Béton Armé*, April, 1907, pp. 52–58.

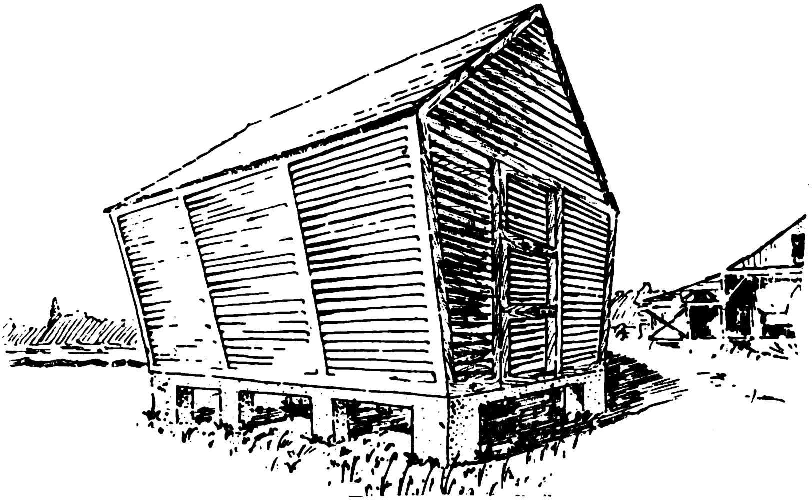
CONCRETE FLOORS FOR BARNS AND GRANARIES.

How to Free the Farm of the Destructive Rat.

In view of the recent plague of rats in the Eastern Counties, the following bulletin, issued by the Department of Agriculture, of Washington, U.S.A., should be useful to all those erecting farm buildings of every description.—ED.

RATS destroy grain, carry "catching" diseases from house to house, and from their love of matches cause destructive fires. This useless waste has become such a loss in America that the Department of Agriculture at Washington, D.C., has issued a free bulletin on "How to Destroy the Rat." To get rid of the rat, remove his nesting place. With this object in view the Department recommends concrete floors, especially for barns, poultry-houses, corn cribs, and granaries. The experience of many farmers is, that grain mature enough to be placed in storage will not spoil on concrete floors. The Government bulletin says: "Corn will not mold in contact with them, provided there is good ventilation and the roof is tight."

For a corn crib choose a well-drained site. Excavate a trench for an 8-in. concrete foundation wall around the outside of the building and to the depth of 2 ft. With box forms of 1-in. siding on 2-in. by 4-in. studding, carry this 8-in. wall to a height of 12 in. to 18 in. above ground level, depending upon the height of the drag-belt conveyors used by local corn shellers. (All concrete floors should rest on a fill bringing them entirely above the surrounding ground.) See that the forms line up and test them for levelness by means of a carpenter's level.



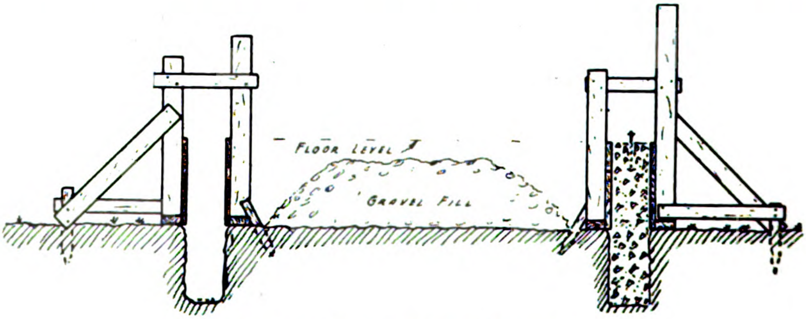
BARN WITH RAISED CONCRETE FLOOR.

On a tight mixing board mix the concrete 1 part Portland cement to 2½ parts sand and to 5 parts crushed rock (or 1 part Portland cement to 5 parts gravel), all measurements by volume, based on 1 bag of *loose* cement, being equal to 1 cu. ft. Fill the forms with concrete thoroughly wet and do not remove them for four days.

There are several ways of attaching the studding to the concrete floor. One of the simplest and easiest is the nailing sill or plate, generally a 2-in. by 6-in. piece, bolted to the concrete foundation wall. For such a sill, while the concrete is still soft, set ⅝-in. bolts 8 in. to 10 in. long, head down, 3 in. in from the outer edge of the foundation wall and projecting 2½ in. above the concrete. These bolts should be spaced not more than 3 ft. apart.

Some farmers prefer to counter-sink the nailing sill so that its top will be flush with the surface of the floor. So placed, the sill is liable to rot more quickly. Others firmly imbed strap loops, made of old tyres, with the loop ends encircling the studding. Do not sink the wooden uprights into the concrete. Timber rots in a few years; concrete lasts for ever. Sometimes studs so placed swell and crack the concrete.

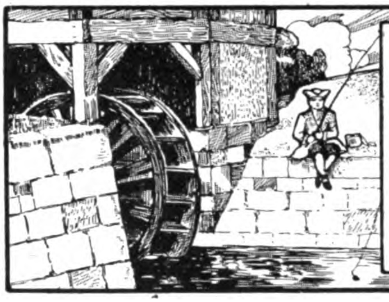
After the forms are removed, place a well-rammed fill between the foundation walls and within 4 in. of their tops. Coarse gravel and crushed rock are the best materials for this purpose. If some clay must be used, tamp it in the bottom, but let the floor rest on at least 6 in. of gravel or crushed rock. With the fill thoroughly settled, commence placing the 4-in. floor. This concrete should be only wet enough that it will flush a little liquid cement when tamped into place. Begin at one end and lay the floor crosswise in 3-ft. sections. Bring the surface of the floor flush with the top of the foundation wall, and, with a straight edge, round it up slightly (say, 1 in.) in the centre. Dress it down with a wooden float, and, when the cement begins to stiffen, smooth the surface with a steel trowel. Continue placing the floor in sections until the work is completed. *Build the floor early* enough *in the season* that it may be thoroughly dried out before grain is stored on it.



METHOD OF CONSTRUCTING THE FOUNDATIONS.

Experienced concrete workers often use only an outside board form, one wall, for the foundation walls. They place the concrete for the foundation wall against this outside form, and at the same time tamp the gravel fill back of the concrete. In this case the foundation, as well as the floor, is built in sections, and both at one time.

Reinforced concrete floors, not supported by earth or gravel fill but by the foundation walls alone, can and are being successfully built. Since the strength of each floor, on account of the variation in size and loading, is a different problem, it is advisable to refer every piece of such work to a man who is thoroughly familiar with the principles of reinforcing. The main point is that concrete floors last for ever, and they afford no nesting place for rats.



REINFORCED CONCRETE RISING MAIN ON THE BONNA SYSTEM FOR THE CITY OF NORWICH.

By E. R. MATTHEWS, A.M.Inst.C.E., F.R.S.E.

We give below particulars of the new sewage pumping main recently carried out at Norwich on the Bonna system of reinforced concrete pipes, which work should be of great interest to our readers.—ED.

One of the most interesting pieces of engineering work in this country in which the Bonna System of reinforced concrete pipes has been introduced is the new sewage pumping main for the City of Norwich, and through the kindness of the City Engineer of that city, Mr. Arthur E. Collins, M.Inst.C.E., the author is able to reproduce some of the drawings, and to present much useful information regarding this important work.

The contract was let to the Columbian Fireproofing Co., of 37 King William Street, E.C., who have carried out in the United States and on the Continent a great deal of work on the Bonna System.

The internal diameter of the pipes was 36 in., the length being about 4,500 yds. The depth of earth covering varied from 16 ft. to 2 ft. Where it crossed the river as an inverted syphon, the pipe was 16 ft. below water.

The cost of the pipes was between £9,000 and £10,000, inclusive of specials, laying and jointing, but exclusive of excavation. Tenders for steel pipes were obtained, the lowest being about £12,000 for longitudinal steel pipes. The lowest quotation for cast-iron pipes was between £17,000 and £18,000—in each case exclusive of excavation.

Mr. Collins informs the author that he did not test the pipes before laying, but that since they have been laid they have been regularly pumped through by reciprocating pumps, also Roturbo pumps—the working head, including friction, at the greatest rate of delivery being 120 ft. He considers the pipes to be quite safe at 300 ft. head.

The pipes can be laid and jointed more rapidly than iron pipes with run and caulked lead joints ; the job, however, was hindered by delay in preparing trenches, due to great influx of water. Where straightforward work was possible, 30 pipes, 3 metres long, were laid per day. This number, Mr. Collins informs the author, could have been increased to any extent by employing more men.

The jointing was carried out as follows:—*Fig.* 3 : Take the section of joint in *Fig.* 1 as an example, the end of each pipe was formed with a rebate ; two adjoining lengths of pipe having been butted together, the slight space between them was pointed solid with cement-mortar ; a band of thin sheet steel was clamped tight all round the pipe leaving an opening about 3 in. sq. at the top of the joint ; the bond was made proof against leakage by being clayed around the edges ; molten bitumen was poured into the annular space formed by the rebated ends of adjacent pipes and the steel band ; the steel band was then carefully removed, the clay also removed, and a ring

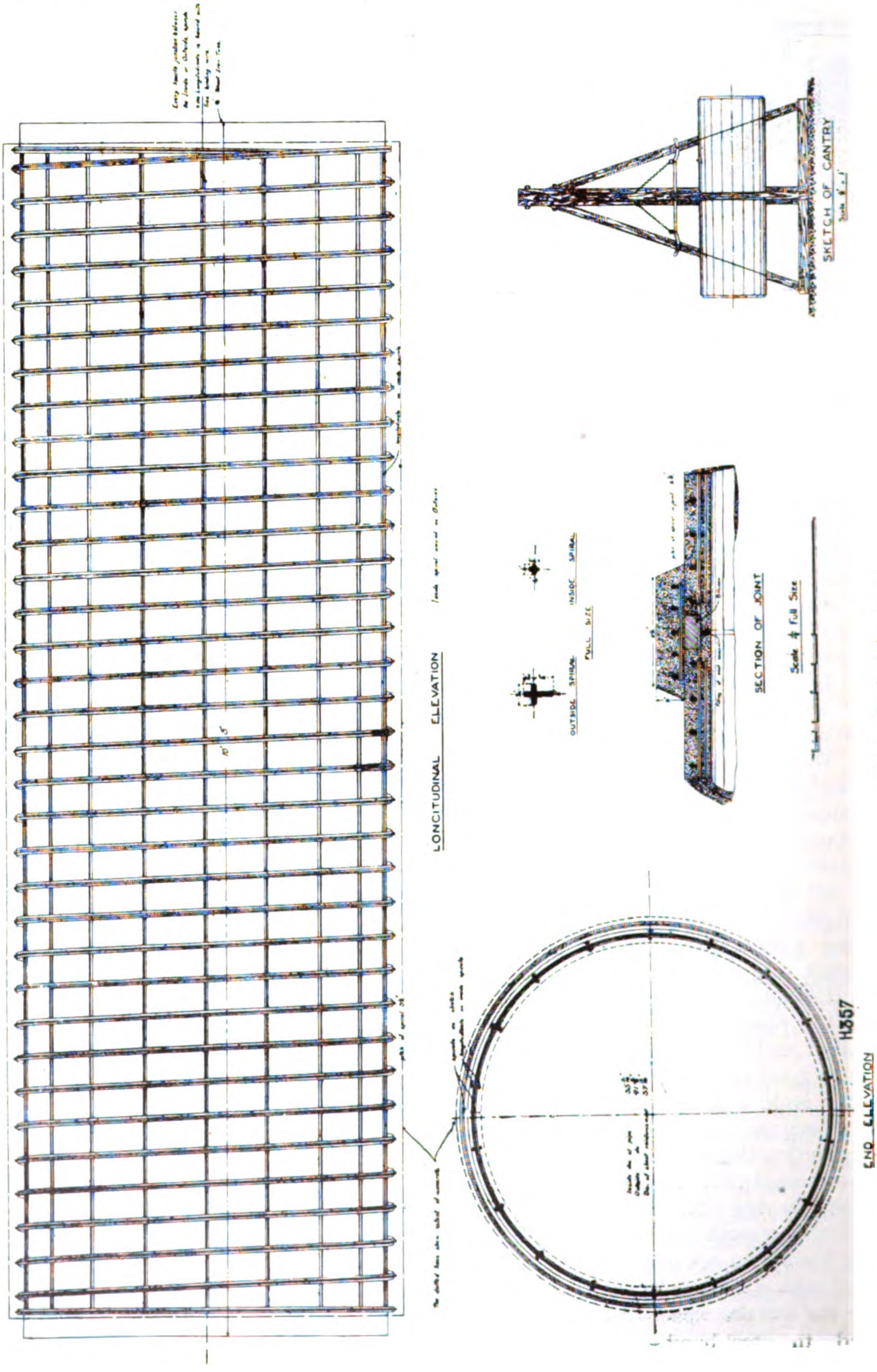


Fig. 1 Steel reinforcement.
Reinforced Concrete Rising Main, Norwich.

of reinforcing steel, previously threaded over the pipe, was drawn over the joint; a 3-part mould was then clamped around the joint, this mould having a large pouring hole at top, and cement-concrete of the same composition as that used in the pipe itself was poured in. The concrete was kept in a state of agitation by striking the outside of the mould and by agitating from the top during pouring. When the cement had sufficiently set the mould was removed, and the joint was then complete.

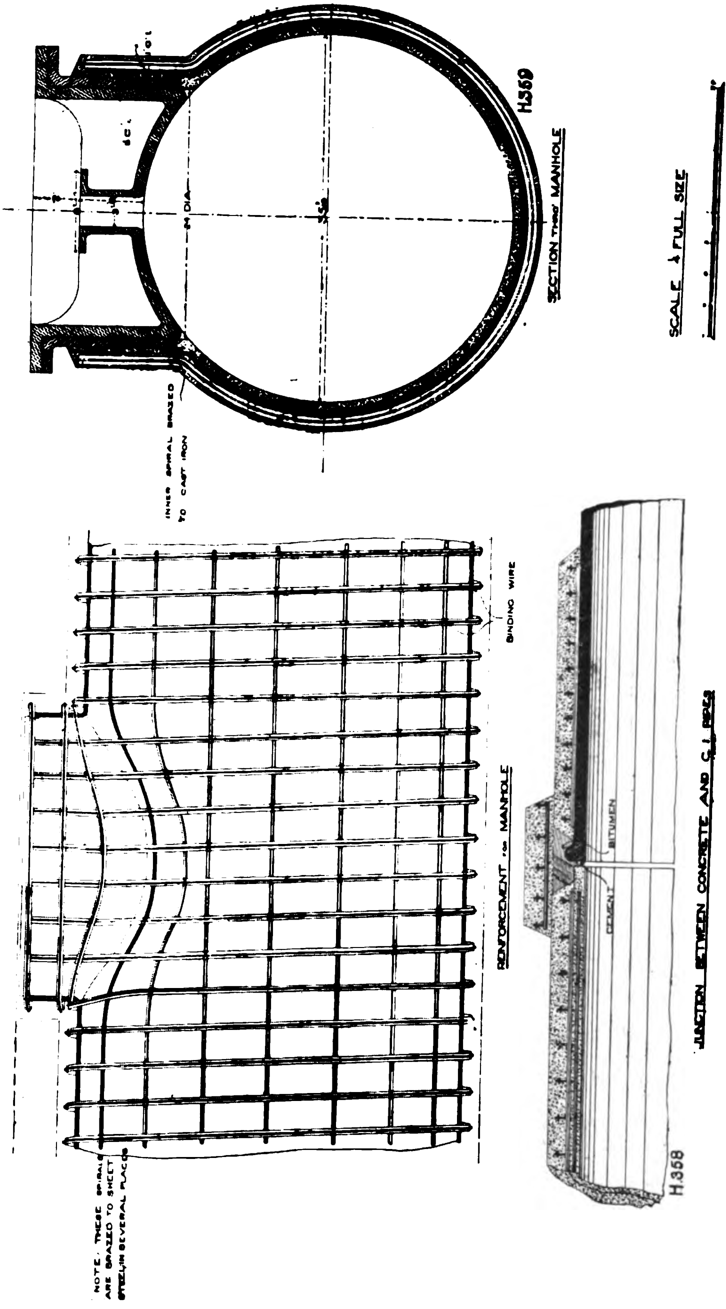

H369
SECTION THRO' MANHOLE
SCALE [illegible] FULL SIZE
36" DIA
INNER SPIRAL BRAZED TO CAST IRON
BINDING WIRE
REINFORCEMENT OF MANHOLE
NOTE: THESE SPIRALS ARE BRAZED TO SHEET STEEL IN SEVERAL PLACES
JUNCTION BETWEEN CONCRETE AND C.I. PIPES
BITUMEN
CEMENT
H.358

Fig. 2. Junctions for manholes.

REINFORCED CONCRETE RISING MAIN, NORWICH.

GENERAL METHOD OF CONSTRUCTION.

The general method of construction was as follows:—The pipes used were 10 ft. 3 in. long by 36 in. internal diameter, and thickness of walls about 3 in. A thin sheet steel tube was constructed, all the joints of which were welded by oxy-acetylene or oxy-hydrogen blowpipe. This tube ran the whole length of the pipe and was flanged slightly at each end. It was encircled with a spiral (see *Fig.* 1) of + section wire of the larger size, shown in

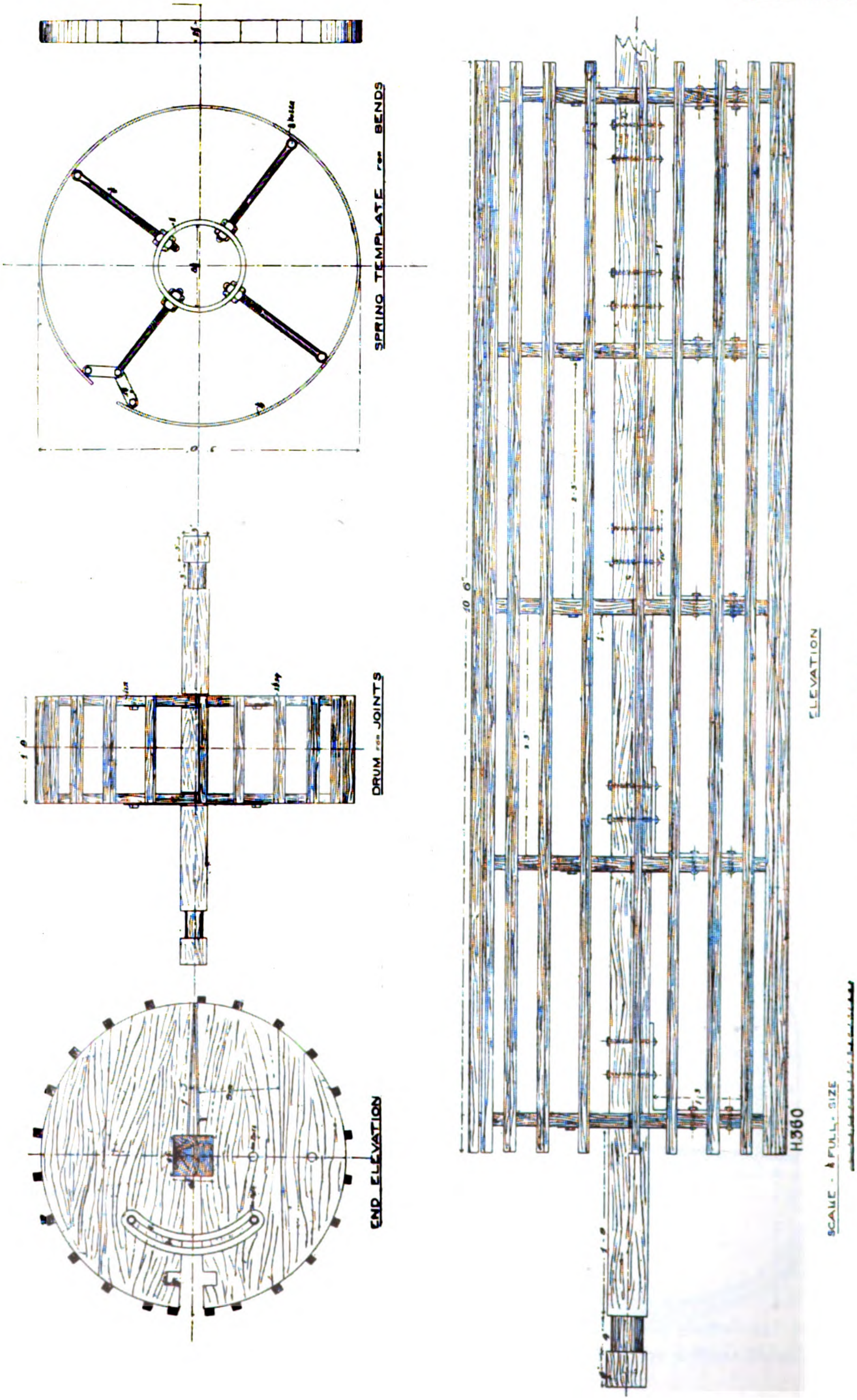


Fig. 3. Drum for reinforcement.
Reinforced Concrete Rising Main, Norwich.

this figure, and lined with a spiral of + section wire of the smaller size, also shown. In the Norwich pipe the amount of metal in the outside spiral was sufficient to resist the whole of the bursting stresses, no portion of this load being assigned to the thin steel tube or the internal reinforcement. The external spiral

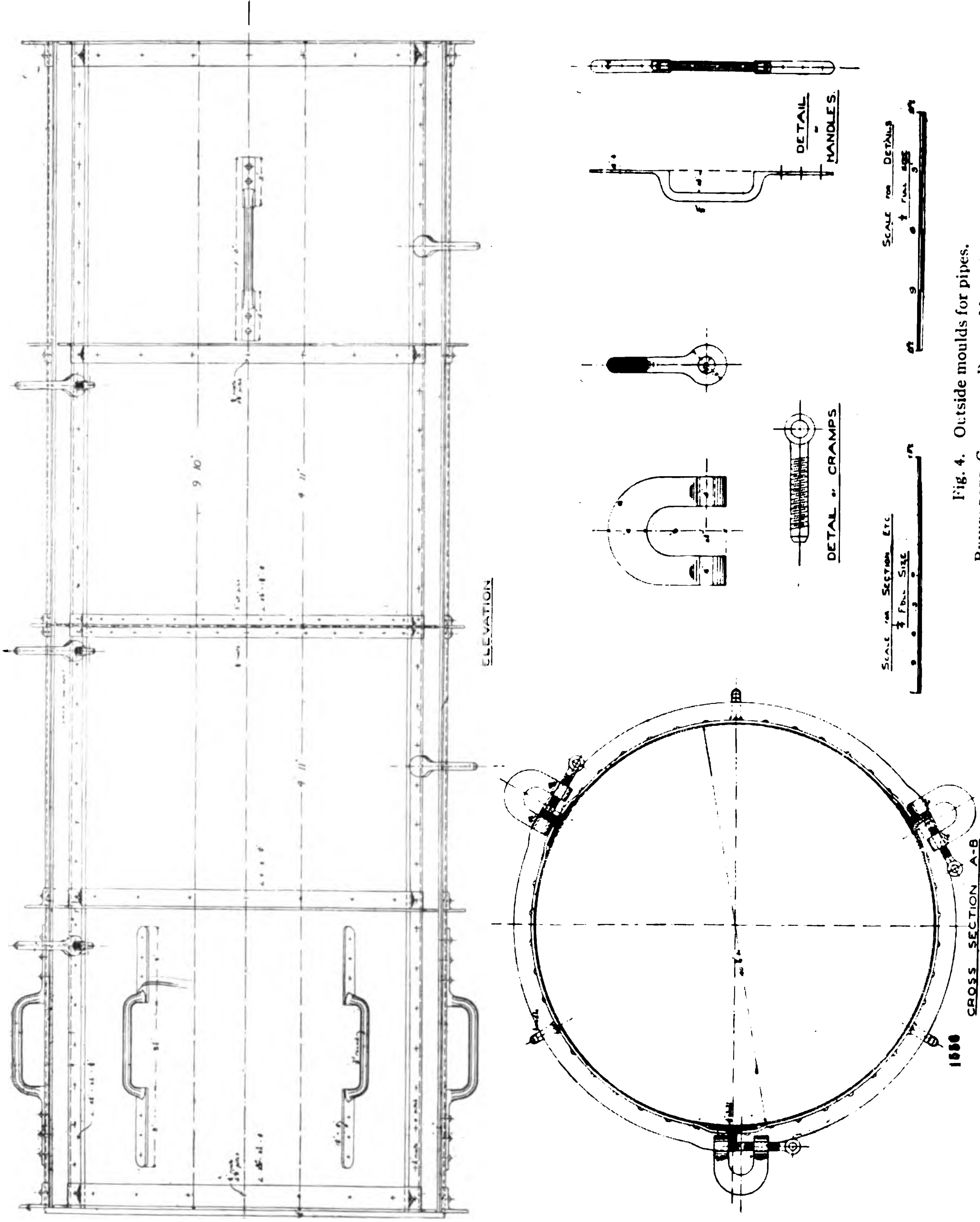


Fig. 4. Outside moulds for pipes.
Reinforced Concrete Rising Main, Norwich.

had, in addition, to act as a bond for the external coating of concrete; the internal

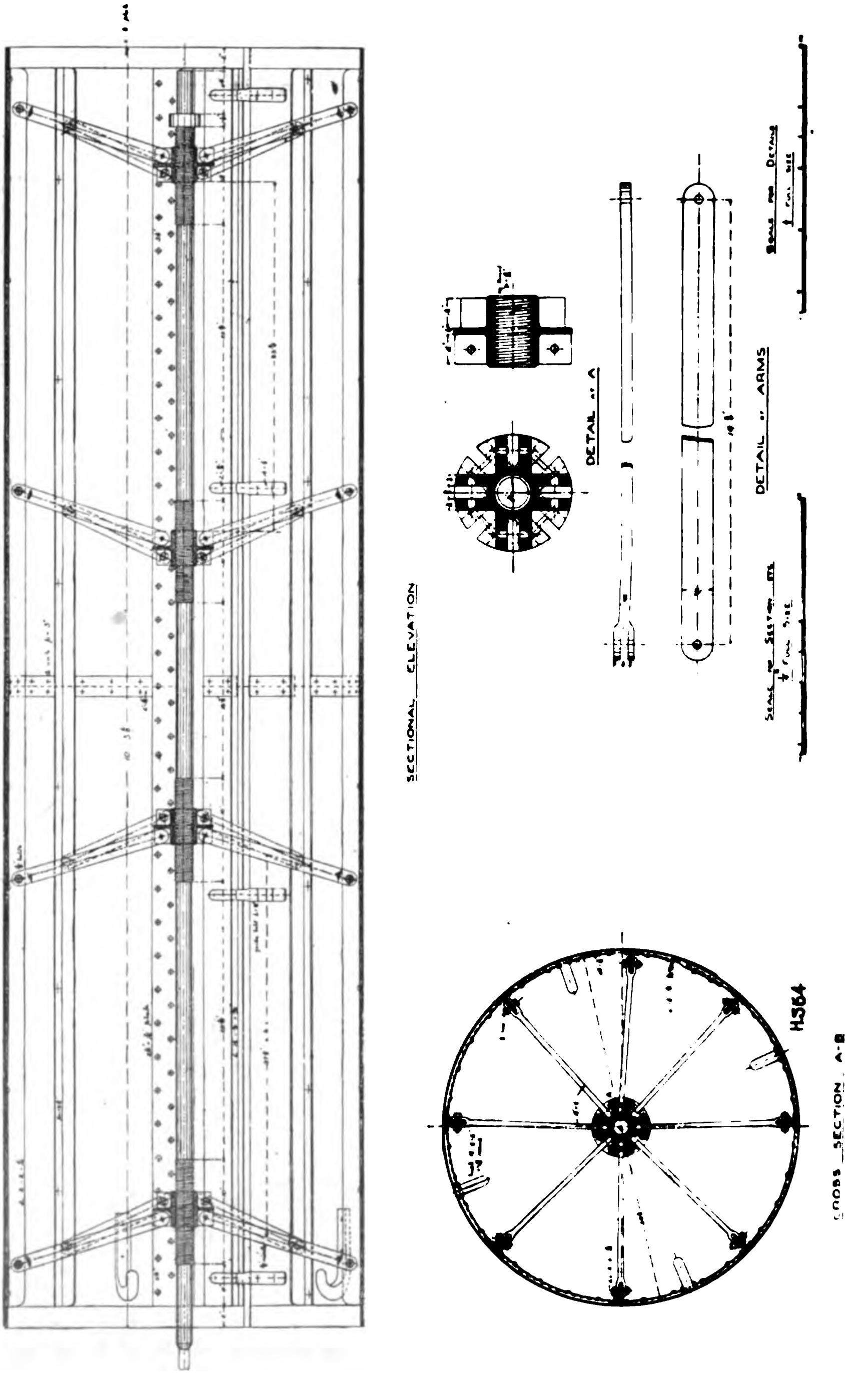


Fig. 5. Inside moulds for pipes.
Reinforced Concrete Rising Main, Norwich.

spiral acting in this manner for the internal coating of concrete. + section steel wire of the larger of the two sections, shown in *Fig.* 1, was wound into a spiral on a collapsible drum, as shown by the elevations in *Fig.* 3. Any joints in this spiral were welded in place by oxy-hydrogen or oxy-acetylene blowpipe. The longitudinal + section wires of the smaller section of *Fig.* 4 were attached on the inside of the spiral by means of wire ties at about each alternate intersection.

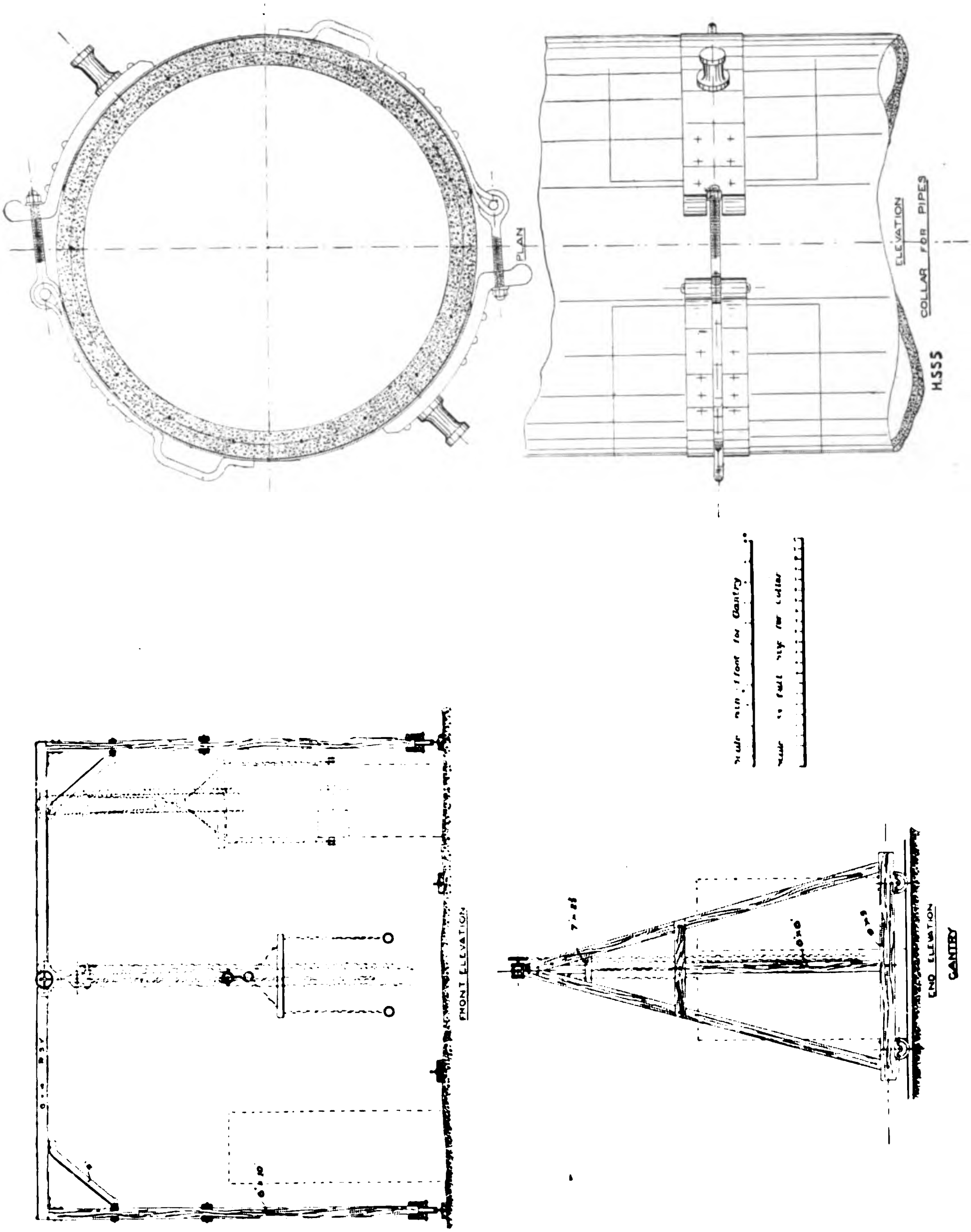


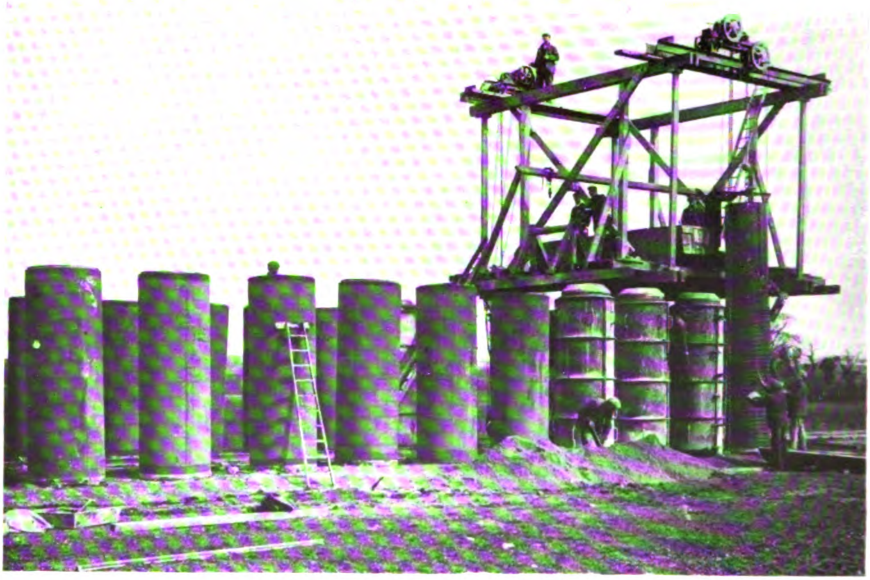
Fig. 6. Pipe lowering gantry.

Rising Main, Reinforced Concrete, Norwich.

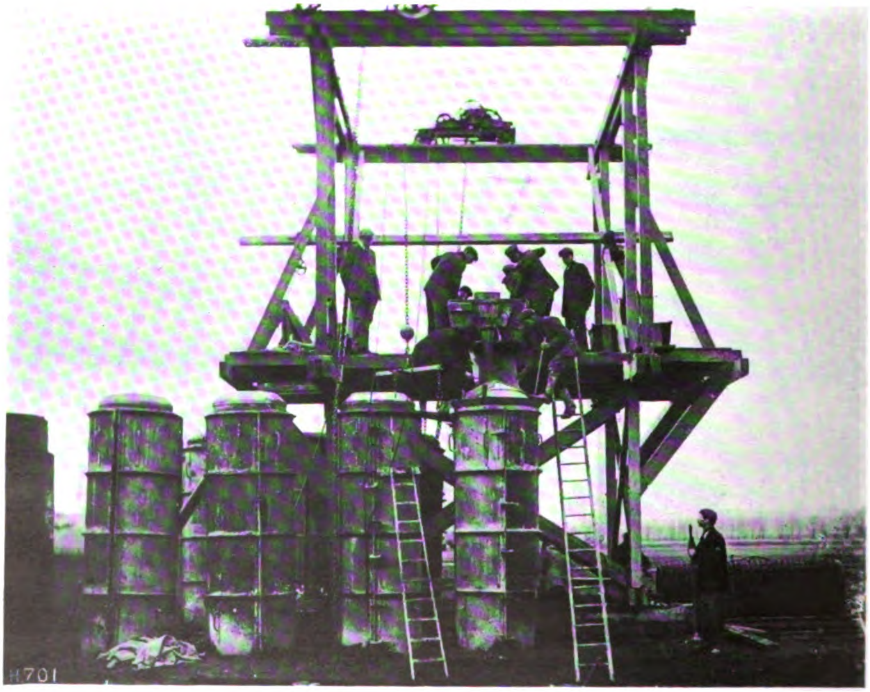
The external spiral was drawn over the steel tube ; the internal spiral was placed inside the tube.

The whole assemblage of reinforcement was then placed upright alongside the concrete mixing and casting gantry, where the copes or outside moulds, shown in

Fig. 4, were placed around it, clamped tight, and the collapsible core or internal mould, shown in the sectional elevation and cross section in *Fig.* 5, was placed inside



Pipes in various stages of manufacture.

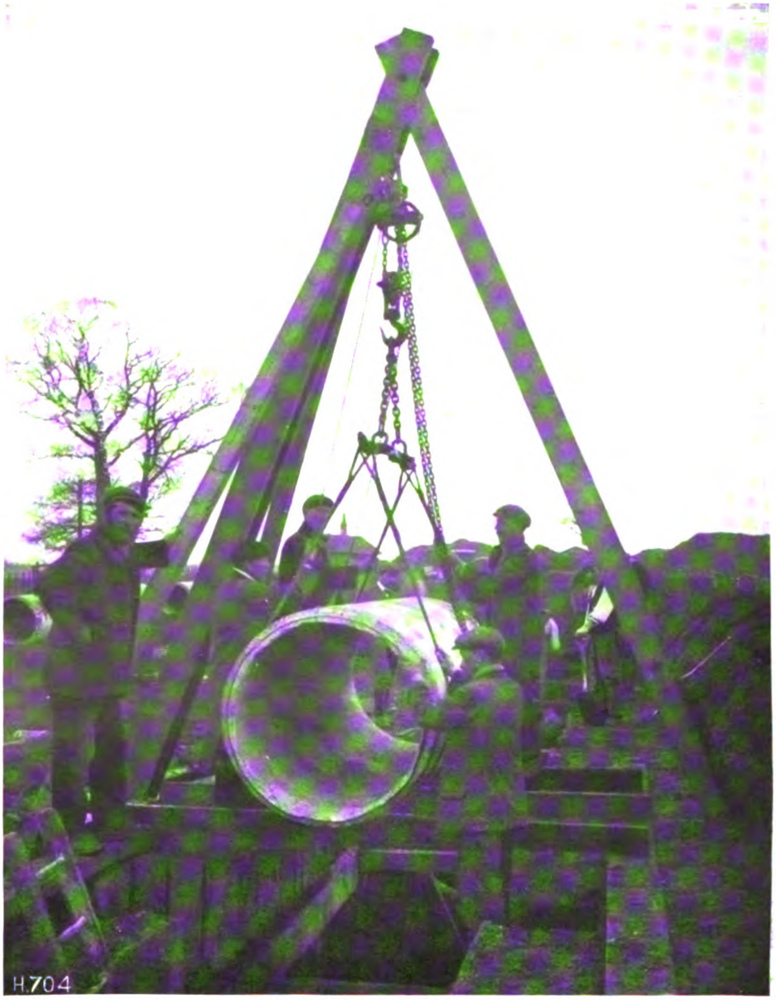


Making Bonna pipes.

Reinforced Concrete Rising Main, Norwich.

it. A cone, with bell mouth, was placed on top to guide the flowing concrete between the core and cope, care being taken that the reinforcement of the cope should be concentric with the core, and concrete consisting of three parts of aggregate to 1 of cement was poured into the mould thus prepared. The core and the reinforcement were kept slightly agitated during the pouring by means of a pinch bar, and the cope was agitated by a series of blows struck by heavy wooden mallets. In suitable weather the moulds could be used twice in a day; generally, they were only used once. As many as 30 pipes have been cast in one day.

Further details of the cope are shown in *Fig.* 4, and of the core in *Fig.* 5 (detail of arms).



Lowering pipe into trench.
REINFORCED CONCRETE RISING MAIN, NORWICH.

The pipes, as moulded, were allowed to stand on end for six weeks before being used. They were then lowered to the horizontal by means of the trunnion and gantry shown in *Fig.* 6.

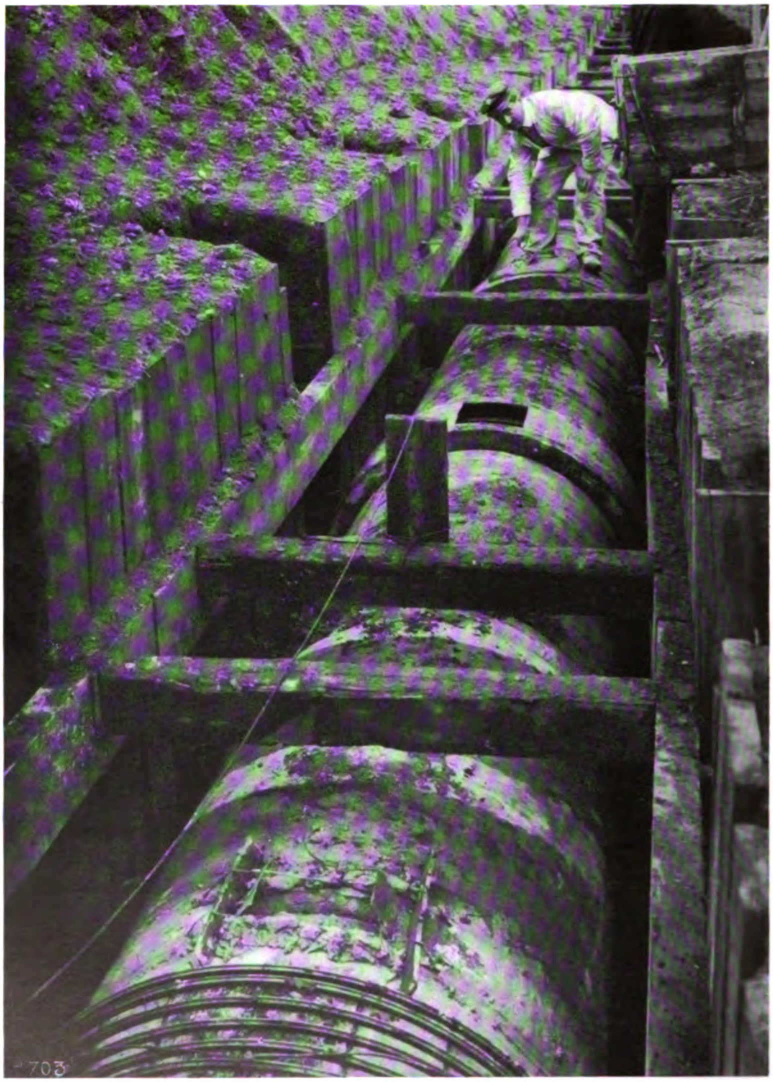
Junctions for manholes or to iron pipes were made as shown in *Fig.* 2.

In *Fig.* 3 an adjustable mandril, or template is shown, for use in keeping the thin steel tube in shape when making bends.

The arrangement of the reinforcement was exactly the same in the case of bends and other specials as in the remainder of the pipes, but being of irregular shape the concrete was trowelled on instead of cast.

The aggregate consisted of flint and gravel sand from a very fine grade up to about 5/16th in. diameter. No crushed material was used.

A complete pipe weighs about 30 cwts.



Jointing pipes.
Reinforced Concrete Rising Main, Norwich.

The main has been in regular use for the past nine months ; there has never been the slightest leakage, or any cause whatsoever for anxiety. Mr. Collins is entirely satisfied with it.

CONCRETE SURFACE FINISH.

As the question of surface finish for concrete is one of considerable importance, we are publishing a very interesting pamphlet issued by the Association of American Portland Cement Manufacturers, which pamphlet consists of extracts from a paper published in "The Architectural Record," by Mr. A. D. F. Hamlin.—ED.

THE treatment of surface is one of the most important matters concerned with the architectural possibilities of concrete. As laid up with care, but purely for utility—a rather wet mixture, well tamped in forms of average regularity, being used—a fairly smooth but regular surface results, a film of mortar settling against the sides of the mould. However, every irregularity and almost every joint of the boarding leaves an imprint. Patches of exposed aggregates show here and there, and variations in colour occur in streaks and layers. In short, such a surface is not merely dull and uninteresting; its inconsequent irregularities are objectionable. Several methods are in vogue aiming at the production of an even texture and one agreeable to the eye. Two quite opposite effects may be had: one consists in brushing and washing away the cement skin, thus exposing particles of aggregate; in the other method a surface mixture of selected material is applied to the surface of the moulds, just ahead of the pouring of the concrete, and, on removal of the forms, the surface may be further finished by washing or tooling.

The first of these methods frankly admits and displays the material as concrete. Some very delightful and varied effects may be obtained by using aggregate of graded sizes and mixing in a certain proportion of pebbles, marble screenings, burnt clay, or broken brick, flecks of colour thus giving an animated texture to the otherwise leaden and lifeless material. Brushing may be done to greater or less depth, giving a more or less roughened surface, as desired. It is necessary to brush and wash the surface while the concrete is still green, as otherwise the process would be too laborious and would be precluded. Therefore the forms must be removed at about twenty-four hours after placing the concrete. The necessity of removing the form work before the concrete has thoroughly hardened considerably limits the practicability of this process. Load-sustaining sections must be hard before the supporting mould is removed from underneath. Where this effect, rather than a smoother finish, is wanted, it should be quite possible to attain it in a measure, even when the concrete is quite hard, by the use of acid and the stone bush hammer. Sufficient of the mortar skin could be removed to obliterate the impression of board veinings and layer marks, and at the same time expose some of the aggregates. After this tool dressing the wall should be brushed down with dilute acid, followed by water played on by a hose to prevent any stains left by the acid.

Exposed aggregates produce decidedly the most legitimate surface, the only proper finish, it might even be said, where consistent concrete design and ornament is carried out. As a matter of fact, the method is best suited, for practical reasons, to buildings of small dimensions, and, artistically, to those of simple wall composition.

In the present transitional period, and quite possibly beyond it, a smoother texture, more nearly that of cut stone, will be considered more desirable for many purposes. Such a finish is arrived at by the method known as *mortar facing*, though it is by no means limited to mortar of the ordinary variety. The most primitive fashion of applying is to trowel on a mortar against the face of the form about an inch thick and for the height of the layer about to be laid and to fill in behind and at once with the ordinary concrete, which, of course, firmly unites with it, as the mortar is still soft. An improvement insuring greater accuracy is to form a slot by means of a sheet-iron plate specially devised for the purpose, with angles to hold it vertically at a desired distance from the face of the forms. The prepared concrete for the facing is first filled into the slot and immediately afterward the backing is poured and tamped down. Then the plate is raised, allowing the two to be firmly bonded together by ramming. When the forms are removed, the facing will require dressing and cleaning down, as, even though the boards have been covered with oil or soap, the soft material will take the impression of grain and joints, and efflorescence may break out in spots. A great variety of texture, and of colour as well, may, of course, be achieved according to the aggregates selected : glistering marble, grey trap rock, yellow sand, and brick dust.

The two principal methods above described, respectively that of outspoken concrete, aggregates showing in relief, and the surfaced-finish, displaying an even, fine texture closely resembling that of cut stone, though it may be coarser, are destined, we think, to characterise two schools of design. Each is in its way legitimate, because harmonious with its own set of ideas and adaptable to widely separated classes of buildings.

We must come to the conclusion, therefore, that in the treatment of concrete surfaces one thing is to be borne in mind—that concrete should be treated as concrete and not as a cheap imitation of any other building material. Concrete construction lends itself with great facility to almost any class of surface treatment.

In giving descriptions of a few methods, which have been successfully employed, they can be classed under two general heads : First, by the insertion into the concrete of various coloured clays or tiles; second, by placing a selected aggregate, in the nature of granolithic finish, on the surface and afterward scrubbing or otherwise treating the concrete surface itself. Both insertions are made at the time the concrete is placed.

Use of Carborundum Stone.—The original idea of monolithic concrete surface finish was a very smooth effect in the nature of a concrete sidewalk. This was accomplished by troweling, but was found to be poor from an artistic standpoint, and also the over-troweling of the surface (very likely to occur) caused the same to crack. By the use of a carborundum stone the same effect may be produced and the surface will not crack. After the forms are removed the concrete must be thoroughly wet with a brush and then rubbed with a coarse No. 16 carborundum stone. Bring the surface to a lather. After this stone has been used sufficiently to take off the rough projections, the lather must be washed off with a brush and the concrete again wet, and then dusted with a mixture of dry sand and cement, the proportions being one part of cement to two parts of sand. This is then rubbed into the surface with a coarse No. 16 stone. Care must be taken not to allow any of the mortar to remain on the surface. The final finish is obtained by rubbing the whole surface thoroughly with a No. 30 carborundum stone. This finish gives a lighter coloured surface than trowelling, fills in any pores that may be in the cement coating, and leaves the masonry more waterproof than it was originally.

Treatment by Scrubbing.—We come now to the second method of concrete surface treatment—viz., the removal of a certain part of the concrete wall to expose other parts of same, and in this way furnish more life and feeling. Either the small aggregate— viz., sand, or the large aggregates, together with the small aggregates—viz., the sand and the stone, may be exposed by this method. There is a slight difference in the placing of the concrete, depending upon whether the large or small aggregates are to be exposed.

In case the smaller aggregates are to be exposed, the concrete should be carefully spaded between the concrete and the surface in the form, as this brings to the surface finish particles of sand and the cement itself.

In case the larger aggregates are to be exposed, no spading should be done, but all the tamping of the concrete should be done in the middle of the wall. This causes the pushing of the larger aggregates (stones) against the surface of the form. In either of these methods the desired colour effects come from the colour of the sand or the stones used in the concrete. These stones should be very carefully selected, with the ultimate colour effect to be obtained constantly in mind. The same selection of aggregates should be used throughout the entire wall, so as to give it a uniform variety of colour. If white limestone is used for one batch of concrete and trap rock the next, the wall would be covered with ugly blotches of alternate black and white, and would present a far from pleasing appearance.

The forms should be removed within twenty-four hours of the placing of the concrete and the surface scrubbed with an ordinary scrubbing brush or wire brush and water, until all the mortar is removed from the surface of the aggregates and their natural colour exposed to the eye.

It very often happens that it is inconvenient to remove the forms in so short a time, and if they are left longer the same results may be obtained by the use of a solution of one part muriatic acid to four parts of water. If this solution is used, the whole surface should be finally washed down with water to remove any particles of the acid remaining on the concrete.

A very successful method, by which practically any colour of surface finish can be obtained, is by the insertion of a metal frame between the concrete and the surface of the form. This can be done in several ways. The one most generally employed with uniform success is to run a line of sheet-iron forms, each 12 in. high and 6 ft. long, across the face 1 in. away from the outside forms. (See *Fig.* 1.) These forms, or "granolithic" plates, as they are called, are held away from the face forms by 1-in. angles riveted vertically on the plate. The plates are allowed to lap each other and several small plates are used to fill out evenly the length of the form. The top 3 in. of the plates are bent backward away from the face to give sufficient room to pour the granolithic mixture between it and the face forms. The concrete and the finishing mixture are poured at the same time, the latter always being kept slightly higher than the former. This prevents any of the concrete itself or cement grout from running between the lap in the plates and down on to the face of the work, as this would disfigure it. The granolithic finish is mixed wet and poured from a bucket into its place. As the work proceeds the granolithic plates are raised so that their top edge is always 6 in. or 8 in. above the concrete. This can be done very easily when the concrete is laid in 6-in. layers. Twenty-four to thirty-six hours after the concrete has been placed the forms are taken down and the surface washed down to remove the sand and cement from between the grits, allowing the latter to stand out and present a very good imitation of granite finish. After washing, the wall is protected from the sun and wet down twice a day for the next three days or longer, depending on the condition of the weather. In washing down, if the washing is started within twenty-four hours of the placing of the concrete and the forms removed so as to expose only about twenty to thirty minutes' work ahead of the scrubbers, then an ordinary bristle scrub-brush will work very well, and very rapid work can be done. If, however, the surface is not scrubbed until thirty-six hours after the placing, or is allowed to stand several hours after the forms are removed, then the scrubbing becomes very difficult, and it is necessary to use a wire brush and only slow progress can be made. In any case a constant stream of water is kept running down the portion of the surface being washed. Some care has to be exercised to make the scrubbing uniform, as too much or too little pressure on the brush will make considerable difference in the appearance of the finished surface. The scrubbers soon get accustomed to this, however, and learn to vary the pressure with the state of hardness of the surface.

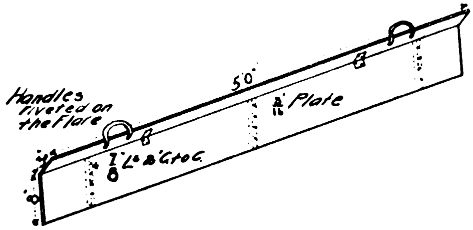


FIG. 1. IMPLEMENT FOR PLACING ANY COMBINATION OF AGGREGATES FOR A FACE AT THE SAME TIME AS CONCRETE IS PLACED.

By varying the mixture of the granolithic finish practically any colour and texture can be obtained. By the use of white cement and crushed marble a beautiful white appearance is secured; by the use of ordinary cement and crushed brown stone a dark brown effect is given. Marble flour with ordinary cement gives light grey. Crushed red granite gives a permanent and attractive colour.

Colouring Matter.—Colouring-matter mixed in mortar is sometimes used to give a uniform colour to the entire wall. The cement, sand, and colouring-matter are mixed together dry, and it is advisable to experiment a little to find how much colour is needed to give the desired shade. The mortar will appear several shades darker while wet than after it has dried.

By mixing five pounds of colouring-matter with a bag of cement the following colours are obtained :

Raw iron oxide will give bright red.
Roasted iron oxide will give brown.
Ultramarine will give bright blue.
Yellow ochre will give buff to yellow.
Carbon black or lampblack will give grey to dark slate.
Manganese dioxide will give black. (Use eleven pounds per bag of cement.)

A mixture of equal parts of carbon black and red iron ore gives dull reds. In all cases the addition of mineral colours causes a loss of strength, but this is not important, since the colour is used only in the surface coat. Lighter shades may be obtained by using one-half to one-third the quantities of colouring matter given above.

Clay Treatment. — If a treatment of artificially exposed aggregate, sometimes called pebble dash, is desired, the following method may be employed :

Erect forms of rough boards in usual manner, in courses of 3 ft. or less. Plaster inside these forms with wet clay. To this wet clay apply different coloured pebbles in sizes of ¾ in. down to those that will be retained on ¼-in. screen. The pebbles will stick to the clay. Pour in the concrete and remove the forms in the usual time, and after the concrete has become thoroughly set wash off clay with a hose, scrubbing slightly with a brush. The clay will tint the concrete and the pebbles will give a pleasing colour effect.

Any coloured pebbles desired may be used in this way, and in a number of places pieces of broken glass have been embedded in the concrete.

Bush Hammering. — For wall work the surface is sometimes picked with a pointed or toothed tool. This chips off the mortar which may have flushed to the surface and cuts away little particles of the mortar from the aggregate below. The roughening of the surface breaks up the light, gives a lighter, snappier colour to the mortar itself, and besides this exposes the colour of the aggregate below. Oftentimes where gravel is used the stones show rusting and have various shades of browns and reds. This additional colour on the concrete adds a great deal to its appearance, and when the dressing is carefully done it gives as pleasing a surface as can be obtained economically. The dressing removes most of the traces of the form and does away with inequalities which may occur in the work.

The objection to this kind of dressing comes in the removal of the surface mortar, which is the most waterproof part of the concrete. If there is any tendency toward porosity in the mass of concrete, it will absorb more moisture after the dressing than before it, and will accentuate the injury from frost. On well-handled and properly proportioned concrete there is, however, very little danger from this, as the material is of itself very dense and waterproof. The fence around Soldiers' Field in Cambridge, U.S.A., in 1899, was treated in this way. It is in low land along the river, where it is fairly damp. This wall is exposed fully to the weather and is in thin sections, but there is no surface deterioration from the weathering.

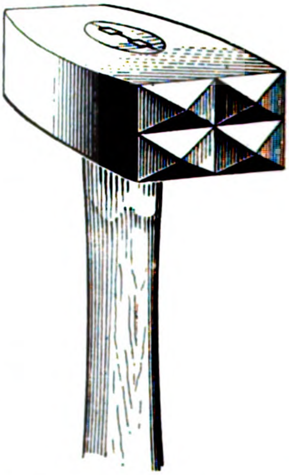


FIG. 2. A TOOL SUCCESSFULLY USED FOR HAND-DRESSING A HOUSE.

This rough picking shows the masonry honestly as concrete, without any imitation of other material. It gives a pleasing surface and one that can well be used on building work. A fairly good Boston example of this dressing is the little subway station on State Street, near Atlantic Avenue. A comparison of the appearance of this dressing and of stone surface is readily afforded by the other subway stations. A labourer with a hand-pick will dress from 40 to 50 ft. of concrete surface two to three weeks old in a day. With a pneumatic tool labourers will get over 50 to 60 ft. There is but the slightest difference between the work of the hand tool and the machine tool.

The depth of the cutting and the fineness of it can, of course, be varied to suit the conditions. This is the surface that the architects use generally for their landscape and other ornamental work. From the point of economy as well as good looks, this dressing for wall surfaces deserves attention.

Two methods of bush hammering have been successfully used in the preparation of concrete surfaces—viz., hand hammering and hammering with an air tool.

In hand hammering the concrete should be allowed to stand at least three weeks after placing, and the longer time given it, up to three months, the more artistic will be the result of the surface. This is due to the crystallization of the cement. In three months it becomes practically as hard as the stone going to form the larger aggregate, and the stone, as well as the cement, is broken by the bush hammer, thus giving life to the surface. In case the concrete is left for longer than three months, the bush hammering becomes very difficult, as the concrete gets so hard that hand hammering has very little or no effect upon it. Various weights and sizes of hammer have been used. A nine-pound hammer with thirty-two points on one end and twenty-five points on the other, and also the same weight hammer with twenty-five points on one end and sixteen points on the other, have given good success. The tendency, however, seems to be toward having a lesser number of points with a lighter hammer.

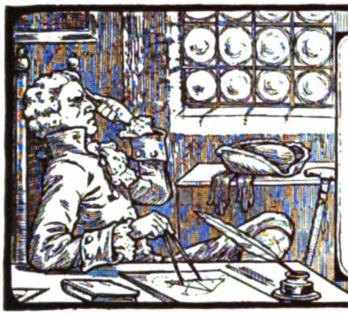
The cost of the bush hammering on this house was from two to three cents per sq. ft. of surface. This is exclusive of the cost of scaffold.

Bush hammering with compressed air has been very effectively used on engineering structures of larger magnitude, where compressed air was available. The Connecticut Avenue Bridge, Washington, D. C., and the Walnut Lane Bridge, Philadelphia, are examples of this method of treatment. The texture of the finished surface very closely represents that of granite.

The few methods of surface treatment given here are of necessity briefly described. Our intent has been to point out the possibilities of surface treatment, giving some few examples of work successfully completed, but to leave to the imagination of the owner or architect the particular combination of colours or surface according with the designs of the houses.

One of the original objections to the use of concrete in house construction was its supposed lack of artistic possibilities, and many yet are of that opinion. If we have succeeded in clearly showing the possibilities of artistic treatment, the object of this book will have been attained.

Sand Blast Finish.—The exposed aggregate effect can also be obtained by what is known as the sand blast finish. This, as its name implies, consists of impinging sand by means of compressed air against the surface of the concrete. This removes the outer skin of the material in much the same manner as scrubbing, and for extensive operations this method proves very economical.



THE CHOICE OF REINFORCEMENT.

Further Contributions.

In our August issue (page 552) we published an article on the choice of a suitable reinforcement, and whilst intimating that we did not associate ourselves with the views expressed—either for or against—we opened our columns to those who have something to say on the subject. Our issues of September, October and November contained contributions, and with the two published in the current number we close the discussion for the present.—ED.

MR. MORITZ KAHN'S VIEWS.

THE correspondents in CONCRETE AND CONSTRUCTIONAL ENGINEERING thus far have dealt with this subject from more or less theoretical points of view. Would it not pay us to examine the principles or economy involved, which appeal to every architect and engineer?

One correspondent claims that the advantage in the use of high tensile steel amounts to 25 per cent. Whatever the advantage, it can only result when the area of reinforcement used is less than 0·4 per cent. of the area of the concrete, as is universally granted, and such instances are somewhat rare.

Another correspondent, when referring to beam reinforcement, stated that in ninety-nine cases out of a hundred the beams support decking slabs, and thus allow for the use of high tensile steel. This is quite true where positive bending moments occur, say, at the centre of the spans; but this correspondent neglects the negative bending moments over the supports of continuous beams, which are even greater than positive bending moments. Over supports, therefore, there is no slab to take the compression forces, and the use of high tensile steel is there prohibited. Nothing is said either with regard to slab reinforcement, where the percentage of reinforcement used makes high tensile steel uneconomical, or with regard to the longitudinal reinforcement for columns. In the latter case it is absolutely extravagant to use high tensile steel, because it is here impossible to develop even the strength of mild steel. Column bases are treated like slabs, and, like them, offer no temptation for the use of high tensile steel. Thus it is clear that the economical use of high tensile steel is practically confined to the bottom reinforcement of beams alone. Let us therefore make a comparison by taking a typical building designed in our office last week, wherein it was found that the distribution of reinforcement was as follows:

	Per cent.
Column bases	8
Longitudinal reinforcement for columns	14
Binding for columns	2
Bottom reinforcement for beams	22
Continuous reinforcement for beams	14
Bottom reinforcement for slabs	28
Continuous reinforcement for slabs	12
Total	100

Instead of percentages let the figures represent tons, and the comparison will still hold good. Without granting the truth of the statement, assume that your first correspondent was correct in saying that the use of high tensile steel gives 25 per cent. extra strength. This, in the comparison given, could only apply, as previously stated, to the bottom reinforcement of beams, and he would therefore have saved 25 per cent. of 22 tons, or 5½ tons of reinforcement.

Take high tensile reinforcement at, say, £8 10s. per ton (a very low price), and round rods at £6 15s. per ton (the average or perhaps a high price), and your first correspondent would have used 94½ tons at £8 10s., equal to £803 5s., instead of 100 tons at £6 15s. per ton, equal to £675, with the result that he would have been the loser by £128 5s., or, in other words, he would have paid about 20 per cent. more than the cost of the commercial round rod reinforcement for the sake of high tensile steel. Surely this does not argue for any economy in the use of high tensile steel!

So much has already been said about mechanical bond that it seems superfluous to discuss the subject further beyond remarking that any deformity which places metal out of the direct line of stress must result in some of it being wasted.

Your correspondents have limited their discussion to high tensile steel and mechanical bond. Are these the only considerations involved in choosing a suitable form of reinforcement? Would it not be as well to consider the value of shear reinforcement and rigidly attached stirrups? It has been repeatedly proved in tests that uniformly loaded beams when tested to destruction fail by shear, and neither high tensile steel nor mechanical bond will prevent such failure unless suitable provision is made for the shear stresses.

In the various systems of reinforcement different methods are used for this purpose. The writer, being connected with a particular type of bar, does not feel disposed to expound the merits thereof in a technical article, which should be an unbiassed one. He would merely ask that consideration be given to all the principles involved, and that it should not be limited to the subjects contained in your previous articles.

MR. R. W. VAWDREY'S REPLY TO A PREVIOUS CORRESPONDENT.

I NOTE that you propose to close the discussion in your December issue, but as the correspondent in your November number has made a few quite incorrect statements regarding the points raised in my letter in October, I trust you will allow me sufficient space for a very short reply.

It is difficult to understand why your correspondent mentions that certain beams when tested to destruction failed by the "end concrete suddenly bursting away from the beams." Quite so. But it disproves his point. Obviously the short length of smooth bar embedded in the concrete beyond the edge of the abutment, in the length of anchorage, was insufficient.

He then makes the remarkable statement that the failure was not due to the slipping of the reinforcement. This amounts to really that the concrete bursts away from the bars, but that the two materials do not separate from each other. I confess that this is inexplicable to me.

Shear members are then mentioned.

The insertion of these, vertical or otherwise, has no *direct* effect on the anchorage of the main tension bars. Of course, *indirectly* there is a great effect, as they reduce the stress in the ends of the main tension bars, and thus diminish the necessity for anchorage at the extreme ends of the latter. Possibly it is this indirect effect which your correspondent has misunderstood. The reason for anchoring smooth bars by fish-tailing, bending, etc., is, of course, that the slipping stress is greatest at the ends, and that it is therefore possible in this way to assist the adhesion at its relatively weakest point. But if only the end anchorage were necessary the ideal reinforced concrete beam would consist of two separate members—a concrete strut and a steel tie rod below it. We have, however, got a little beyond that idea now, though I am ready to admit that in the quite unusual case of a permanently evenly loaded beam the adhesion at the centre of the tension bar ceases to be of any importance, and the " strut and tie " principle might be adopted for a foot or two in the centre of the beam. In actual practice it is, of course, out of the question.

The further statement is made that it is just as necessary to fish-tail, split, or otherwise anchor indented bars at their ends as smooth bars. Your correspondent must surely have some altogether fresh view as to the reason for fish-tailing smooth bars. May I suggest that the general idea is that it is for the purpose of anchoring them in the concrete, and as it is really a truism that a good mechanical bond bar does actually increase the anchorage of such bar (I am sure your correspondent will agree with this statement, whether he considers the anchorage necessary or not), it follows that a smooth bar needs anchorage more than an indented or other mechanical bond bar.

One more point, a minor one (from the *theoretical* point of view). It is absolutely incorrect to state that the smooth bar is a much more economical form of reinforcement than the mechanical bond bar. Many forms of mechanical bond bars can be rolled and purchased at a price very slightly, if at all greater, than that of smooth bars. On the other hand, the advantage of obtaining reinforcing bars from rolling mills which are specially laid only to supply such bars is very considerable.

CHEAP COTTAGES IN AGRICULTURAL DISTRICTS.

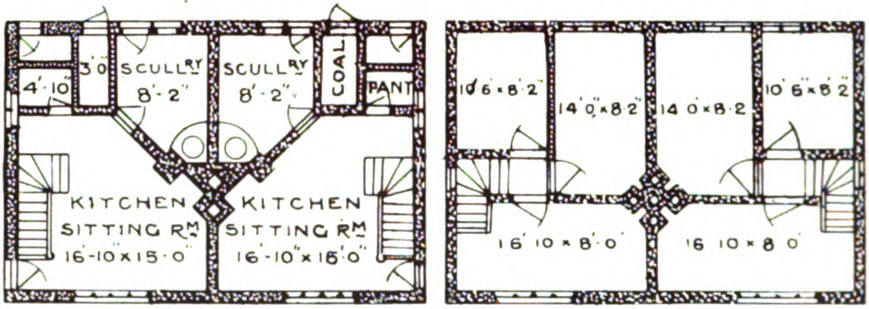
We have observed with much interest of late the increasing use of Portland Cement for concrete blocks among owners of estates for small dwellings for their agricultural labourers. There is no doubt that for districts where a suitable aggregate is easily obtainable concrete block lends itself admirably to buildings of this kind.—ED.

THE question of providing cheap sanitary dwelling for the agricultural labourer has attracted the attention of land owners as well as social reformers for very many years past, but it was only in 1905 that the agitation came to a head, and an exhibition of small holdings, both for agricultural labourers and dwellers in urban districts, was formed in connection with the first Garden City at Letchworth. In that exhibition of dwellings there were several examples showing how concrete might be used in various ways. In some cases the walls were constructed by plastering metal lathing with cement mortar; in others, solid concrete walls were moulded *in situ*; solid, and also hollow, concrete blocks were adopted. One example showed how walls might be moulded all in one piece as a slab, and erected in position and joined at the corners. The particular local conditions at Letchworth did not show any material saving in cost to be effected by the use of concrete, but it was shown to a large section of the public how advantageous concrete was from the point of view of hygiene and durability.

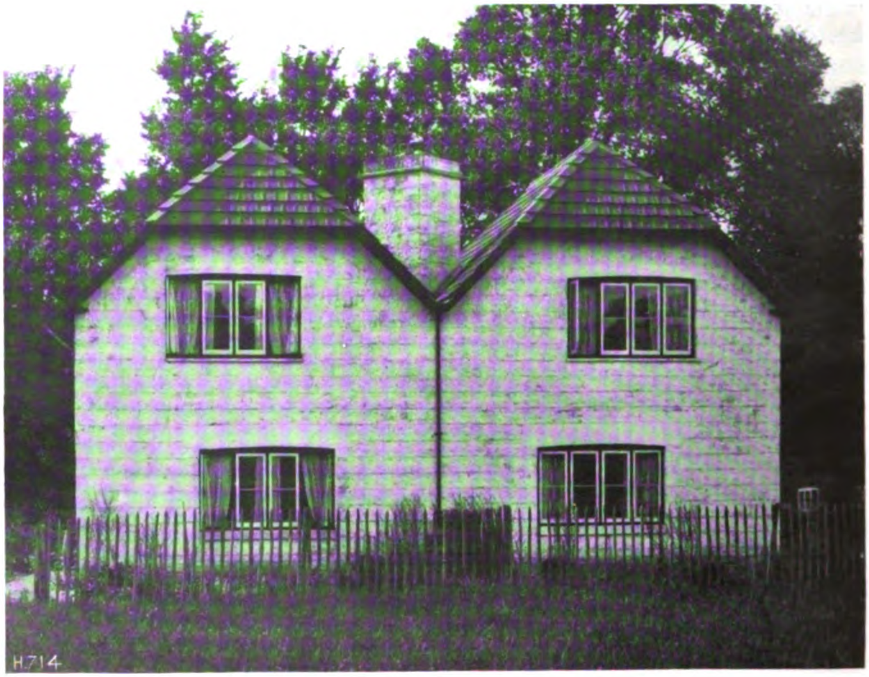
Since that exhibition the endeavour to construct buildings for agricultural districts for £150 each—which was the cost that was put forward as the ideal to strive after by those connected with the exhibition—progress has been made in the application of concrete, and now Mr. St. Loe Strachey, the Editor of *The Spectator*, to whom we are indebted for our illustrations, brings forward an instance where he has had cottages erected with concrete blocks built for his gardeners at that figure. We reproduce below the letter which appeared in *The Spectator* in which Mr. Strachey gives his personal experiences of these buildings:—

THE question of the cheaper housing of the people in rural districts—the problem of the cheap cottage—is still with us. Indeed, it may be said that it is destined to become more acute. There are signs that we shall obtain, owing to various agencies, a considerable increase of small holdings. But new small holdings require houses and buildings for the small holders. Meantime the spread of industries, great and small, into the country is increasing the demand for cottages. May I give your readers an account of how I was able to build a pair of cottages for £300—that is, for £150 each?

The first thing to settle upon was a form of construction which would be cheap, and at the same time durable. Luckily for me, a local builder of intelligence had visited the first Cheap Cottages Exhibition, held at Letchworth in 1905. What he saw there induced him to adopt the system of building with concrete blocks, and he designed for himself a cheap but very practical machine which turns out excellent blocks (composed of Portland cement and gravel) 18 in. long, 9 in. high, and 9 in. thick, with two square holes in the middle, holes which practically make the wall a hollow wall. These blocks are not only in themselves cheaper than a group of bricks of equivalent bulk, but they have the advantage of very greatly decreasing the builder's labour bill. The use of so large a unit, though it is a unit not too big for a man to handle, especially if he has the help of a little simple tackle, makes the walls "rise like an exhalation." Another advantage is that the cost of haulage is distinctly lessened. The house arrives on the site in the form of a big heap of gravel and a great many bags of Portland cement. All that is then wanted is a good supply of water. The next thing is to bring the very simple block-making machine, which can come upon a hand-cart, and to set to work to make the blocks, which can best be described as giant cement-bricks. The making is very easy, and can be done by unskilled labour as long as the labourers are conscientious as to the manner in



Plan of Cottages at Newlands.



Mr. St. Loe Strachey's Cottages, built of Concrete Blocks.

which they mix the material. The blocks, as soon as made, are ranged in rows round the foundations of the house, which are dug out in the usual way. There they are allowed to lie for a month in order to set. The concrete blocks are in a month quite set enough to build with, and the process of hardening them goes on rapidly. The inside wall, even if left by itself as it is in the scullery and other offices, is by no means impossibly rough ; but in the living-rooms it is, of course, covered with a hard plaster, which goes direct on to the wall. The inside partition walls are built with thinner cement blocks.

It will be noticed that the chimneys are all grouped together in the middle of the house, an arrangement which is economical not only of blocks in the building, but of fuel in the future. Note also that the staircase rises out of the kitchen-sitting-room, and is not boxed in. This is done in order to increase the air-space of the room and to save charges. The greater part of the visible woodwork outside is tarred, but the actual window-frames are painted.

The chief objection which will be raised to the house is that there is no sitting-room or " front room." I admit that I expected that this would prove a source of difficulty, but I am glad to say that it has not proved so. As a matter of fact, the scullery is so near that everything except the application of the heat to the meat is performed in the scullery.

I add my builder's account. It will be seen that practically there is no profit for the builder, and I must acknowledge with thanks my builder's loyal co-operation with me to keep the price down. Of course, one cannot expect builders to work for a possible profit of about 1½ per cent., but in many cases it is not necessary to allow for a builder's profit. On a great number of estates the cottages are built by the estate masons and carpenters. My contention is that in these cases landlords who will take the trouble to study economy in every particular can build thoroughly comfortable and sanitary cottages for £150, or rather pairs of cottages for £300. I may add that I had to buy the gravel for the blocks at a neighbouring gravel-pit and have it hauled to the site. If the site on which the cottages had been built had either been "sharp" sand or gravel, the blocks could have been made from the material dug out of the foundations. In that case the total cost might have been reduced by £16.

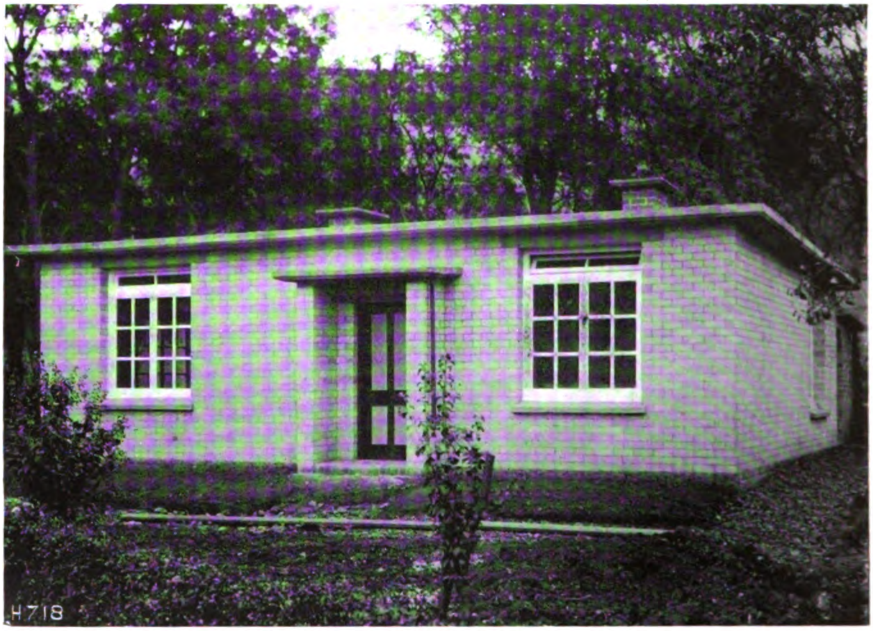
Approximate Detailed Net Cost of each Part of the Work.

	£	s.	d.
Making plans and setting out cottage … … … … … …	2	10	8
Digging gravel and sand, and haulage to site … … … … …	16	2	0
Making the concrete blocks, including cement … … … … …	65	15	2
Digging footings, building walls, including cement … … … …	30	17	3
Making doors and windows, including timber and fittings … … …	35	7	1
Framing joists and floors, partitions and roof, including timber … …	52	15	5
Tiles for roof and lead for gutter and fixing ditto … … … …	23	6	1
Making and fixing stairs and linings and shelves, including materials …	13	19	7
Lathing and plastering, including materials … … … … …	31	11	9
E.C. fittings, sinks, coppers, cooking stoves, grates, eaves-guttering and pipes, and staining and varnishing … … … … … … …	13	2	5½
Builder's profit, to cover use of tackle … … … … … …	5	12	6½
	£300	0	0

In districts where bricks cannot be cheaply obtained, and in cases, too, where there is a heavy cartage required on materials from the local station, concrete has a distinct field of usefulness. In such conditions, too, it is not always possible to use stone, and, indeed, where local stone is obtainable, the cost of dwellings is often very high. In all such circumstances, without exception, suitable aggregates can be obtained for the making of concrete, and the only cartage that has to be done is that of the cement, timber, and fittings. A small moulding machine for blocks can be carted to the site, and blocks quickly and cheaply turned out. Mr. St. Loe Strachey's example of how to build a concrete house at £150 is of material service, because it is applicable in any part of the country.

WORKMAN'S BUNGALOW DWELLING.

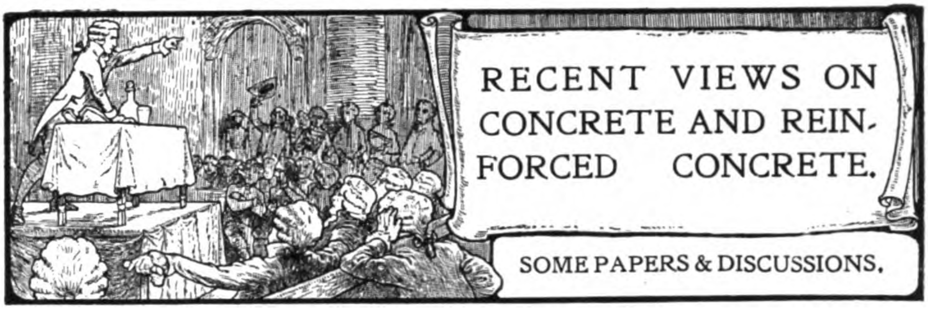
Following this subject of suitable cottages for agricultural labourers, we are publishing another illustration of a workman's dwelling of the bungalow type, which was constructed of brickwork. This example will have particular interest to our readers, because it shows the application of reinforced concrete in the construction of a flat roof. This was constructed of reinforced concrete 4½ in. thick, and forms an excellent tie to the walls. The sills are of concrete; also the window and door heads. The eaves project 15 in., and the roof pitches to 1 pint of rain-water being taken off by one downspout. The low cost of this roof effected a great saving over any other durable material. The whole of the cottage area was covered with 6 in. of cement concrete. The by-laws permit the use of lime concrete for this purpose; but considering the cheap price of cement, nowadays, and its far superior qualities, it is the general custom to apply Portland cement concrete, and lime concrete is falling into desuetude.



Workman's Bungalow Dwelling.

The cost of the cottage was £160, including foundation work. Repairs, rates, and ground rent are charged at £2 5s., and this, with interest on the loan, would allow for a rent of 3s. 6d. per week. There are three bedrooms; in this case also the kitchen and sitting-room are combined (19 ft. by 14 ft.), and there is a washhouse at the back.

The dwelling in question was built by Mr. Fred Ballard, of Colwall, Malvern, who is a member of the Herefordshire County Council Small Holdings Committee and Health Committee.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE INSTITUTION OF CIVIL ENGINEERS.

PORTLAND CEMENT AND THE QUESTION OF ITS AERATION.

Paper by Mr. H. K. G. BAMBER, F.C.S., Assoc.Inst.C.E.

At the Ordinary Meeting of the Institution of Civil Engineers held on the 22nd November, Mr. Alexander Siemens, President, in the Chair, the Paper read was "Portland Cement, and the Question of its Aeration," by H. K. G. Bamber, F.C.S., Assoc.Inst.C.E. The following is an abstract of the Paper:

MUCH has been said and written on the subject of Portland cement, but in connection with the chemical or physical side there is still a wide field for research, as uncertainty exists on many of the complex problems which continue to baffle skilful investigators. The methods of manufacture in the past were known to but few, who with well-established brands of a new and eminently useful material, had practically a monopoly of the trade in the United Kingdom, and, for a considerable period, of the trade of the world. Contrary to the practice during recent years, when the engineer has prepared the specification detailing the properties of the material he proposes to use, the manufacturer then held the engineer in the hollow of his hand. The increase in the number of cement works in various parts of the country soon caused the supply to overtake the demand, with the inevitable result that the handsome profits realised in the early days of the industry were diminished, never to return to their former level. It was not until a later date and towards the end of the nineteenth century that development on scientific and economic lines was undertaken by many of the principal manufacturers in all parts of the world. Their efforts met with the full appreciation of the members of the engineering profession who, by varied experience, became fully acquainted with the properties and eccentricities of the cements of the past.

Great improvements were brought about through the initiative of Sir John Wolfe Barry, Sir William Matthews, and others, and a scientific system of standardisation has now been established, resulting in great influence for good, as well on the commercial as on the technical side. The industry as a whole, having accepted these conditions, has improved the methods of manufacture by large expenditures of capital in the way best adapted to meet local conditions and the character of the raw materials to be dealt with. The state of things prevailing in the cement industry in the sixties, and the costly and tedious methods which it was generally necessary for the engineer to adopt before the cement then supplied to him could be safely used were due to the almost entire absence of that scientific chemical control which is an essential part of the methods of to-day.

The importance of thorough amalgamation of the raw materials and of the chemical uniformity resulting was not then fully realised, or, if it was understood, no adequate provision was made for producing so perfect a mixture as is now obtained. Further, the subsequent calcination was often carried out in a very perfunctory manner, without any successful attempt being made afterwards to separate the unburned portions from those which were thoroughly calcined. The defects being caused chiefly by the presence of uncombined lime, due either to faulty amalgamation of the raw materials or to insufficient calcination, or to both, the engineer wisely had recourse to the simplest and most natural methods for neutralising its expansive force, by converting the free lime into hydrated carbonate of lime by absorption of moisture and of carbonic anhydride from the atmosphere, with the object of rendering it inert. In treating cement in bulk this is a tedious and expensive process, but with the knowledge then available perhaps no better system could have been devised to secure soundness and freedom from expansion.

Many engineers—especially those whose experience extends over a long period—have become so accustomed to the use of some aerating process that, perhaps by force of habit, they still continue to require it of their contractors, forgetting that cement which has already passed the stringent tests of the British Standard Specification. has necessarily shown itself to be entirely innocent of any expansive tendencies. If this specification is adhered to for all requirements, the old aeration methods have become as obsolete as the ancient machinery of the cement industry which has found its way to the scrap-heap.

The improvements which have been effected, particularly since the end of the nineteenth century, have lifted cement-making to a high position in the list of scientifically-conducted industries. Given efficient chemists, now an important part of the staff, no difficulty is experienced in obtaining continuously a well-proportioned mixture of the raw materials, whatever their character ; and by means of specially-designed machinery these materials are so effectually reduced that it is usual to find 95 per cent.—calculated on the water-free material—capable of passing through a screen of 32,400 meshes to the sq. in. This is as near perfection as it is commercially possible to attain, and with proper calcination, the clinker should contain only traces of free lime, by which is meant amorphous calcium oxide capable of hydration or slaking with expansion, as distinct from the crystalline form in which it is said to exist, together with the silicates and aluminates of lime, in solid solution. Crystallised oxide of lime in this form is thought by some of the most recent investigators of the subject to be relatively inert, hydrating or slaking very slowly without expansion or evolution of heat, whereas the amorphous oxide of lime slakes immediately upon the addition of water, giving off considerable heat with a large increase in volume. It is the absence of lime in this latter condition in modern cements which renders futile any attempt to improve them by aeration.

One of the most important improvements in the manufacturing process is the introduction, on a practical scale, since 1900, of the rotatory kiln. Its advantage is that the calcination is completely under control. The author proceeded to describe the process in detail, and also that of grinding, an operation to which much attention has been given of late years. Another great improvement in the production of sound cement, and the one which renders subsequent aeration unnecessary, is the introduction of the hydration process carried out in conjunction with the grinding ; it consists in submitting the cement, during its final reduction, to a saturated atmosphere at a comparatively high temperature. The process results in achieving in a scientific, rapid, and highly efficient manner what the aerating operations of the engineer have only imperfectly effected on the cements of the past. It also has a markedly beneficial effect in regulating the setting-time, and in rendering it more permanent, by preventing to a large extent the return of the cement to a quick-setting condition, a danger which exists when gypsum alone has been used to retard the setting-time. Lastly, there is the cooling process, where the hot cement on leaving the mill is conveyed to revolving water-jacketed coolers. This operation, being conducted in the presence of air, adds the finishing touch to the beneficial results of the previous hydration.

Contrasting, therefore, the properties of the cement manufactured under rule-of-thumb processes of the past with those of the best cements made to-day, it should not be difficult to convince engineers of the desirability of abandoning an obsolete method of treatment. A means of diagnosis is now in the hands of the engineering profession in the form of the British Standard Specification, and there is no necessity to, as it were, impair the vitality of the patient by treating him for a complaint which can be proved to be non-existent.

AMERICAN SOCIETY FOR TESTING MATERIALS.

THE CONSTITUENT MATERIALS OF CONCRETE.

By RUSSELL S. GREENMAN, Engineer-in-Charge of Illinois State Testing Laboratory.

At the Meeting of the American Society for Testing Materials held in June last, Mr. R. S. Greenman read a paper on "The Constituent Materials of Concrete," of which we give a summary.

To make concrete there are certain essential materials. These are commonly listed as cement, sand, and stone. One other material is important—water. For sand and stone there are several substitutes. It is generally acknowledged that the cement for all large works should be subjected to rigid inspection and tests. On very large works the sand and stone are also carefully inspected. On smaller works the cement has sometimes been tested, but the sand and stone have often been given no more than a casual inspection. Many failures, doubtless, are due to a lack of a proper supervision, but in some cases ignorance of the materials used has permitted the too early removal of the forms and centering. In one case, known to the writer, shavings and small blocks were swept into the forms, a column collapsed, and four lives were the cost of this negligence. When concrete fails, a post-mortem examination shows that proper inspection of workmanship and materials would have prevented the failure.

Cement.—Modern hydraulic cement is of very recent introduction into many of its present uses. Hydraulic cements have been made for nearly a century; but the cement of fifty years ago—yes, of twenty-five years ago—was not the cement of to-day. The latter-day cement that is most generally used is called Portland. Unless concrete is to be put to some extraordinary use, the cement should have certain characteristic qualities. First of all it should be sound, also it should be ground to a certain degree of fineness; it should not set, or harden, too quickly, and it should show, in tests, a good tensile strength. Generally the smaller users take it for granted that a cement of established reputation will always possess these good qualities, and they purchase and accept cement on the name of the brand. Such a practice can hardly be called safe, for mistakes occur in the best-regulated families, and sometimes even the best mill may turn out some lots of poor cement. Cement is unsound usually because it is green, not having had time to cure. After the cement clinker, or the finished cement, has been stored until the free lime has become hydrated, or slaked, the cement generally becomes a safe cement to use. A future cause for failure in this same cement may be from an excess of sulphuric anhydride or an excess of magnesia. An excess of either of these can ultimately destroy what is apparently good concrete.

Upon the fineness of cement depends to a great extent its strength. It is the finer particles that have hydraulic activity. The coarse particles are practically inert and act as so much fine sand. It must not be understood that, of two brands of cement, the finer is necessarily the better; but, of the same kind of cement, that which is the finer is apt to produce better results. There is, however, a minimum percentage for the different degrees of fineness, above which all cement should be ground.

Setting of Cement.—The setting of cement, as defined and limited in specifications, may or may not be important—with one distinct exception It may matter little in the majority of cases whether or not the cement takes thirty minutes or four hours to take its initial set, as the large majority of cement users have the concrete well in place within the minimum time allowed, and only in cases where there is some delay does it make a difference. The exception which always does become a matter of importance, however, occurs when the cement takes what is called a flash-set—setting hard in a very few minutes. Cement of this nature is decidedly improper, and its use should not be allowed. There must, too, be a distinction made between the setting of cement and the hardening, for the latter is of much importance in the making and care of concrete. The setting of cement may be considered as being limited to that time when the cement is undergoing the first chemical action, when the cement crystals are being formed ; the hardening of cement takes place at that time when the cement crystals are gaining strength and continuing more slowly the chemical action which began in the setting. It is of vital importance for one to know that he may be using a slow strength-getting cement. The removal of forms or centering, the care of the concrete itself, the time at which it is safe to place a load upon the concrete—all these depend upon the rapidity of the growth in strength.

Sand.—The first consideration in the selection of sand is generally that of cost. The contractor may be willing to pay a larger price for his cement, in order that he may be reasonably sure of securing a satisfactory product, but the sand must be the cheapest that can be procured. This demand of cost, however, is gradually assuming its proper place—namely, at least partially subservient to those qualities which will produce required results. What these qualities are depend largely upon the use to be made of the concrete ; but, as a general rule, the sand must be composed of hard grains ; it must be composed of well-graded particles. It must not have too large a percentage of voids, and it must not contain too much loam and organic matter. However, it must be admitted that it is practically impossible to secure an ideal natural sand, but some sands are so far from the ideal that their use is impossible.

The character of the sand grains is important. The smaller grains are generally quartz, with occasionally some feldspar. The larger grains are particles from broken down sandstone or are particles of shale. As long as the sandstone grains are not from decaying stone these sands are all right ; when, however, they are soft and easily crushed, they will be much weaker than the cement, and add no strength to the mortar. Shale grains are apt to be much weaker than the cement, and if exposed to the weather have a tendency to disintegrate, but with a rich mortar each sand grain would thus be protected from the weather. Feldspar should be coated with cement, as the grain also has a tendency to disintegrate, and its proportion in sand should not be too great. Such sands as contain much mica do not make good sands for concrete, as the mica greatly reduces the strength.

If sands are well graded the percentages of voids are greatly reduced. It is possible by artificial mixture to secure materials with very few voids. For special uses this may be done. For general use it is not practical, but such natural sand should be selected as will show the best graduation in the size of its grains. It has been generally specified that sand shall be a sharp, clean sand. In very recent years we have come to admit that good cement will adhere to a round surface as well as to a sharp, flat surface. We have just seen that a round-grained sand contains less voids than the sharp sand. The word " sharp " is gradually being stricken from the specifications and the words " well graded " are being inserted in its place.

There is often used as a substitute for sand the finer product of the stone crushed for use in concrete or macadam. This product is called crusher dust, or screening ; it often makes a splendid substitute for sand ; in fact, it often produces better concrete. This will happen when the particles are well graded, the use of either sandstone or limestone screening proving very satisfactory. It often happens, however, that the screening contains a large percentage of very fine dust, and with this there is also a large amount of particles of about ¼ in. to ½ in. size, without a proper proportion of the intermediate grades or sizes. The result is that, when used in concrete, the cement becomes adulterated with the fine dust and the concrete is weakened. It is true that this fine dust will aid in producing an impervious concrete, but it also makes a more tender concrete—one that will not well stand the shock of impact. There has been introduced into some use within the past few years a waste product that makes a very satisfactory substitute for sand—namely, iron-ore tailings. As a rule this is well-graded material and produces a very satisfactory mortar.

Stone.—The selection of the stone to be used as the aggregate for concrete should be given very careful consideration. It frequently happens that a gravel can be secured more easily and more cheaply than a satisfactory crushed stone. As a result we have two main classes of concrete—broken stone and gravel. Both have good points in their favour. Another kind—cinder concrete—has a field of its own, and is the best concrete that can be used under certain conditions. In the selection of the stone or gravel we have problems similar to those which are presented in the selection of sand. The same question of voids, size, the grading of the stone, and cleanness are all vital considerations. There is also the further question of strength. It is necessary that, since the stone forms by far the larger part of the concrete, it shall have a strength approximately the same as the cement. The kind of stone is the first point to be given consideration, the selection depending somewhat upon the use to be made of the concrete. Good, hard stone is absolutely essential. Hardness and toughness, density and weight, help to determine the stone. Traprock and granite generally produce the best concrete ; hard limestones also give good results ; sandstones are generally quite as satisfactory ; but stones of a shaly nature should be avoided. When gravel is used, it is equally important that it should be composed of good, hard pebbles. Shaly gravel should not be used. No stone or gravel of a soft or decomposed nature should be permitted in concrete.

The question of cleanness is very important. It is almost sure destruction to concrete if the stone is coated with loam. The coating prevents a proper adhesion of the cement to the stone and with this lack of adhesion the concrete becomes similar to honeycomb—sawdust is then just as useful as stone. One of the arguments made against gravel concrete is that there is a greater danger of the pebbles being coated with dirt. It is often not only advisable, but necessary to wash the gravel. In this case it might be a better plan to secure crushed stone, as a freshly-crushed stone should not be coated with dirt.

Quantity of Water Used.—The question of quantity of water used in mixing concrete is not always a vital one. Where massive concrete work is put in place, large quantities of water are used and the supply, naturally, will be a satisfactory one. There are times, however, when small structures are to be erected at some point distant from a large supply of water. It is natural that the contractor should then look for the nearest supply. The source of this supply should be examined before its use is permitted. As an illustration : The concrete in a certain culvert failed to set. At first the cement was blamed. Investigation brought out the fact that other culverts in the vicinity had been constructed with the same cement, sand, and stone, and were perfectly satisfactory. Attention was then given to the water. This water was taken from the creek flowing through the culvert, and when this creek was followed it was found that it flowed past a medicinal laboratory where bark and herbs were largely used. The creek was decidedly affected by the waste from this laboratory. This point well illustrates the effect of organic matter on water and concrete.

Any source of supply that gives very silty water should not be used while it is in this condition. It is possible to allow the suspended matter to settle, the water may thus be satisfactory. Water that is brackish, or leaves any deposit in the nature of a slime, should not be used.

Placing Concrete in Frosty Weather.—There are certain conditions in the use of concrete that are interesting and deserve consideration, but they do not really come under the head of this article. However, the question of placing concrete during freezing weather is an important one, and, in conclusion, a moment or two may be spared with profit in its discussion. Everyone admits that it is better not to do so, but conditions sometimes necessitate doing concrete work in the winter months. If the concrete is not subjected to varying temperatures—that is, if the concrete could be frozen and kept frozen until the winter was over, it could be placed at any time. But as we have very variable weather, and since it is not possible to put our concrete in cold storage, we have only the alternatives of not putting it in at all or protecting it against the action of frost. But, as has been said, necessity sometimes demands that concrete shall be put in. To lessen the harmful influence of the frost, several methods are followed. When the concrete is not to be a decorative feature there is nothing much better than the use of salt. Calcium chloride has also been used in the same way. When it is wished to avoid any possible efflorescence—due to the salts—the aggregates are heated before being used. This latter method becomes effective only when the concrete is protected from the frost until it has acquired a set and has hardened considerably.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.

CONCRETE CONSTRUCTION IN THE COUNTRY.

Paper by ERNEST WILBY, Architect, Detroit, Mich.

The following is an abstract of a paper on "Concrete Construction in the Country," read at the Second Convention of the Canadian Cement and Concrete Association.

JUST now all kinds of movements are on foot for the beautifying of our cities. I should like to see a similar movement for the beautifying of our rural districts; the first is a work of great difficulty, the latter, with the aid of concrete becomes, I believe, very simple.

Usually in obtaining an artistic result, as for example in cement houses, that result depends on the quality of the design; the designer must be an artist, that is to say, an architect with artistic knowledge and training.

Bridges.—Canada and the United States, being newly-settled countries, have had to meet the problem of opening up the land for occupation by rough and ready methods, little thought being given to so immaterial a thing as beauty. This is especially noticeable in our bridge work. First came the wooden bridge, not altogether without merit, and then in the search for something more durable that triumph of ingenuity, the modern steel trussed bridge, a tall attenuated arrangement of struts and wires, beautifully scientific but not by any means scientifically beautiful.

The small steel bridge is an eyesore, and endurable only so long as we cannot replace it with some other form of construction more beautiful, while being practicable and inexpensive. Concrete seems to offer us these three advantages.

It is not my purpose, however, to dilate on the practical and economical advantages of concrete construction for bridge-work, but on the artistic results which follow its use; concrete as a material is in harmony with almost any natural setting as soon as it is in place. Large surfaces of cement are never monotonous, the texture of the surface gives endless play of light and shade; it also forms a satisfactory background for trees and shrubs; the solidity of the material gives a satisfying appearance of permanence and stability, the absence of which is fatal to all beauty in the steel or wooden bridge.

Ever since the arch was discovered, some 2,000 odd years ago, no other form of bridge construction has been invented which, in beauty of form and durability, can compete with it. To appreciate fully how much we lose by not having adopted hitherto this form of bridge construction, we have only to visit England, France, Germany, Italy, or Spain. In each of these countries we find the arch bridge of every size and kind used since time immemorial, each one beautiful and a harmonious note in the landscape. Now, at least three parts of this beauty is not the result of design, it comes from using the arch form. The arch is in itself so beautiful that other things matter little.

We cannot hope to reproduce these bridges in stone, the expense makes that impracticable. In most localities concrete offers the one and only material; it is a good substitute if used for what it is and not in imitation of stone. While the arch form is applicable to concrete construction, I regard it as essential that the use and shape of the arch be such that no steel reinforcement be needed to give it stability, it must not only *be* strong but it must *look* strong. For this reason the eliptical arch is not to be commended; the arch needs only to be semi-circular or segmental, in some cases it may be pointed, any of these forms will look well.

It would be preferable to use monolithic construction throughout the bridge. Cement blocks could, however, be used for the arch when they would be more practicable, provided the rock-faced variety were not used. In country districts a high finish is not necessary, a degree of rusticity being more harmonious with the natural surroundings. In this case there would be no objection to simplicity as a safe path to follow, any attempt at decoration is dangerous unless done by a trained designer.

A word about steel reinforcement. There would be no objection to its use for the purpose of giving strength and homogeneity, provided no attempt be made to alter the structural line of the arch. As I said before, the beauty of the bridge depends on the line of the arch, which would be similar to a masonry arch, so that it will have the appearance of being self-supporting and of having ample strength to support the weight resting upon it. In a number of cases when the arch bridge has been used in the United States, the mistake has been made of giving excessive rise to the crown of the bridge. A few inches of rise sufficient to overcome the optical effect of sagging is desirable, but should be so slight as to be barely perceptible.

Farm Buildings.—That other blot on our landscape, those flimsy, restless constructions of wood we call farm buildings, are much in need of a more permanent and sightly building material. Stone is, again, out of the question on account of cost; brick also is expensive, and unless a good quality is used, properly laid in cement mortar, and resting on good foundations, it is not permanent. It is also difficult to handle in an artistic way by any but a trained architect, and the usual farmer is not likely to employ one.

Now, a farm house and the adjoining buildings should not only serve the purpose for which they are built, but should look the part, should belong to the country, be as much a part of it as the trees, a growth of the soil, not merely resting upon it, but a part of it. To accomplish this a solid building material is essential, the structures must have stability, *be* permanent, and look so; added to this, the material must harmonise in colour and texture with its environment. Concrete will do all this if used with a little judgment.

It is not likely that the artistic value of concrete construction will appeal to the farmer. If he uses it it will be on account of the low cost, permanence and ease of handling. However, if he be persuaded to use it for its practical advantages, and not be led astray by mistaken desire to imitate stone, or to reproduce the features of a town house—if he will only use concrete for what it is, build simply, without any effort to add architectural details, in all likelihood the result will be good.

Farm buildings, from their shape and size, fall naturally into good lines. Generally, they are long and low, with much unbroken wall and roof surface, the windows, doors, and other openings, are few in number. If to these conditions we add stability, a pleasing wall and roof texture, we then have all the essentials of a good building.

One valuable characteristic of concrete is its neutral colour which, in the majority of cases, blends perfectly with nature's colour scheme. In concrete for farm buildings I believe the best effect will be obtained by using monolithic construction, not cement blocks, for, while the latter is much better than wood, and capable of rendering good service, the necessary joints destroy the repose of surface so desirable from an artistic point of view.

All the buildings should be simple in the extreme. Let the walls and roof be continuous and as long as possible, avoiding all unnecessary breaks, keeping all openings some distance from the corners of the building, in order to preserve the appearance of stability. The roof eaves should project some distance, as this not only sheds the rain, protects the walls below from dampness, but gives a shadow of great value in an artistic sense.

If these simple rules are followed and concrete is used for the walls, and the usual wood shingles for roofs, the combination would result in buildings which fit naturally into the landscape. A few trees would add greatly to the effect. Creepers, also, could be allowed to grow without fear of injury to the walls, thus adding additional beauty.

NEW WORKS IN CONCRETE

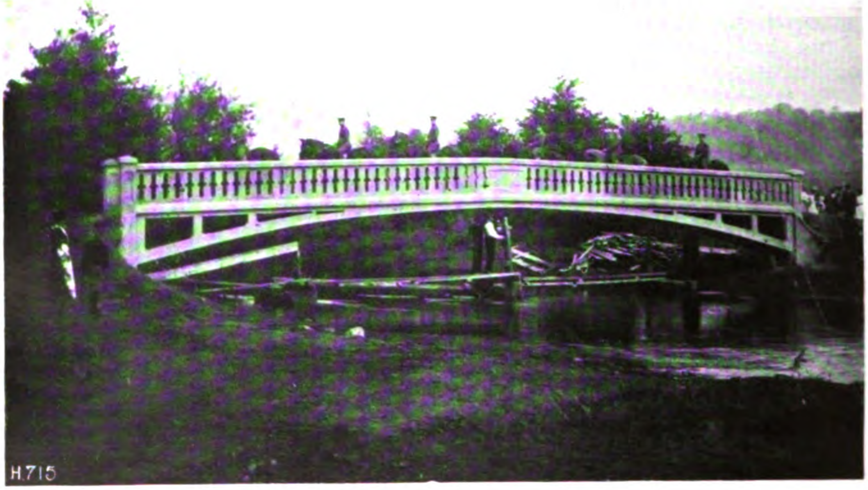
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE BRIDGE AT ROGERSTONE, NEAR NEWPORT, MON.

DURING the heavy floods of the autumn of 1909, the old timber bridge crossing the River Ebbw at Rogerstone was washed away, and the question of a new bridge was taken in hand by the St. Mellon's Rural District Council, who called in Mr. Gomer S. Morgan, Consulting Engineer of Pontypridd, to advise them as to the best form of bridge to adopt. Mr. Morgan decided upon a reinforced concrete structure as being the most suitable from the point of cost as well as of maintenance, as the question of painting meant something like £10 every four or five years.

The work was placed with Mr. Gwilym L. Morgan, of Pontypridd, and erected on the Hennebique system.



View of completed bridge during the test
REINFORCED CONCRETE BRIDGE AT ROGERSTONE.

The structure was completed and tested within ten weeks of the commencement of the work, which, of course, was very rapid, the test being carried out by means of allowing a detachment of the Royal Field Artillery to first walk over the bridge and then return on a trot, and was perfectly satisfactory, as the maximum deflection, which was recorded by means of an automatic instrument placed under the bridge at the centre, was $\frac{1}{28}$th of an inch, equal to $\frac{1}{23500}$th of the span of 70 ft. As will be seen from the photograph, the parapets are of a very ornamental design.

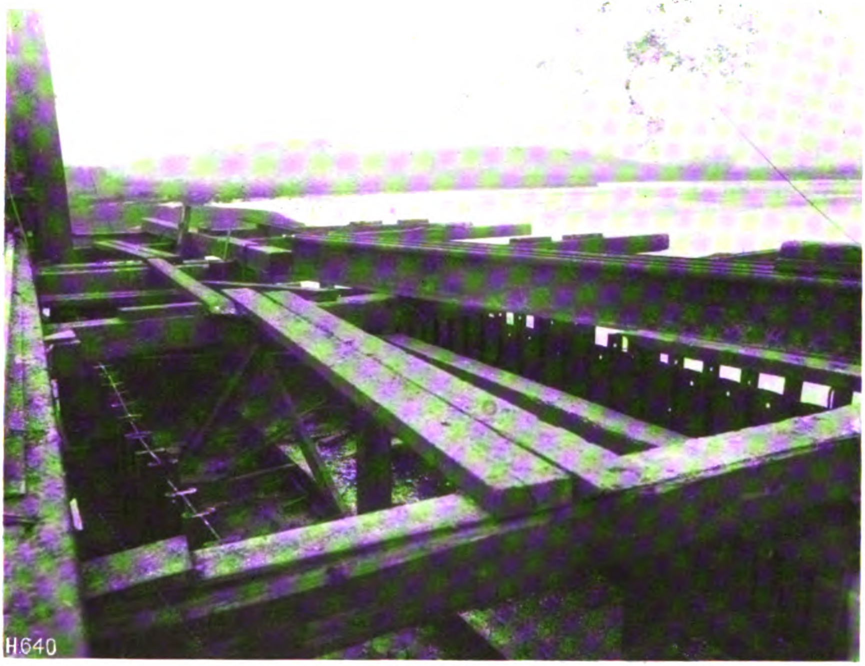
COFFERDAMS FOR VIADUCT AT LOUGHOR.

THE illustrations on pages 921 and 922 show a portion of the cofferdams for the piers of the viaduct which is to carry the new line to Fishguard over the river Loughor. There were in all twelve cofferdams to construct—two being on the land sides and ten in the river, and sufficient piling was supplied to construct two, so that each set had to be driven and withdrawn six times.

The piles were 35 ft. long and 15 ft. wide, except for a few narrow ones which were used for closing. They were of the "Universal" joist section, weighing 43 lbs. per super ft. when interlocked.

The driving was through running sand and some hard ballast, the piles being driven about 20 ft. Driving was commenced with a plain joist, and then continued with a joist and clutch together, which prevented the clutch filling with soil, and the consequent strain on same when the next joist was driven in, whilst the last pile has two clutches for closing the dam.

The illustration on this page shows one of the completed dams. As soon as the dam was closed the sand was grabbed out, and when down to the required level the concrete was put in for the foundation, and then the brickwork carried up above the high-water level. The piling was then withdrawn and redriven on the next dam.

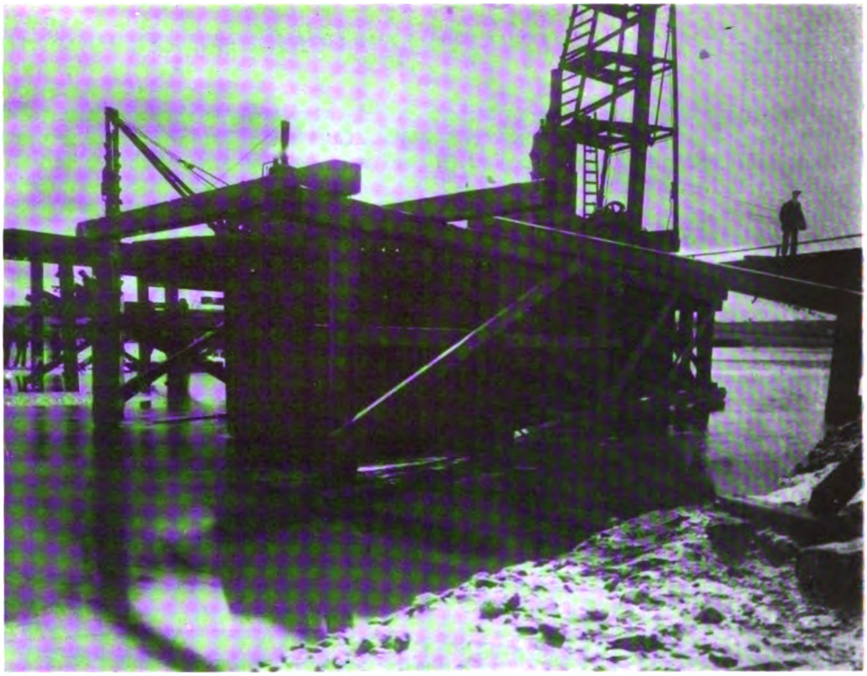


View of one of the cofferdams from above.

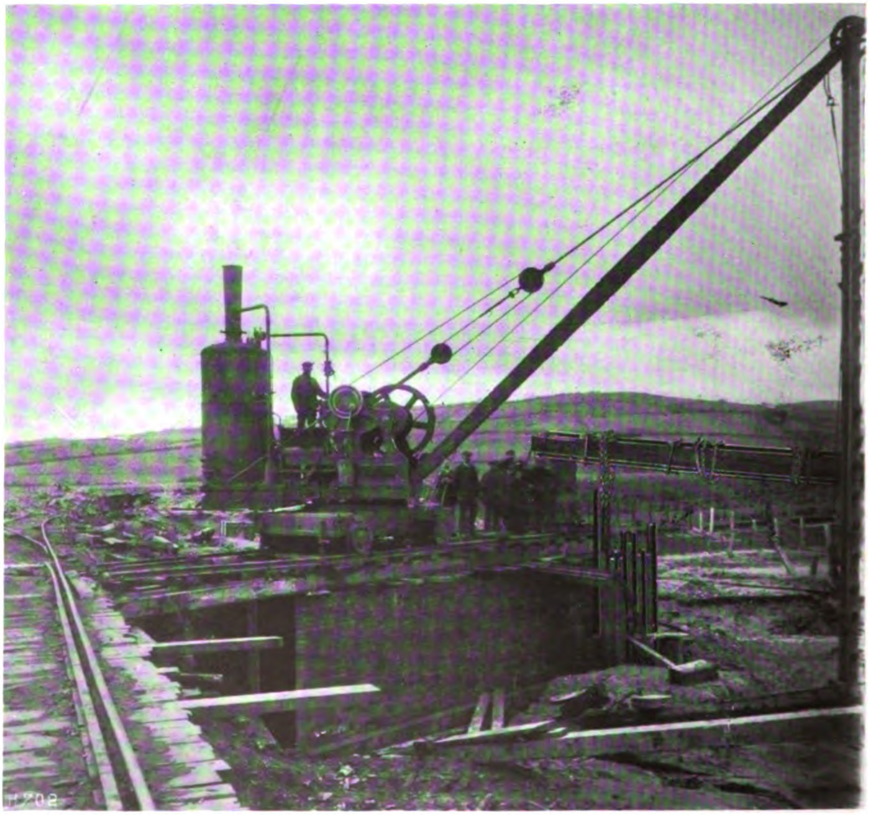
COFFERDAMS FOR VIADUCT AT LOUGHOR.

The construction of the "Universal" joist section is very simple, consisting of a British standard joist or I-beam, with a special clutch or interlocking member made from a joist by turning over the flanges. Each pile, therefore, consists of two members which are driven as one, the clutch being run on the joist before the piles leave the works.

The great saving on this class of work, effected by the use of steel sheet piling, is apparent, as it would be impossible to use timber so often, whilst the cost of driving steel piling is very much less than for timber, owing to the small sectional area.



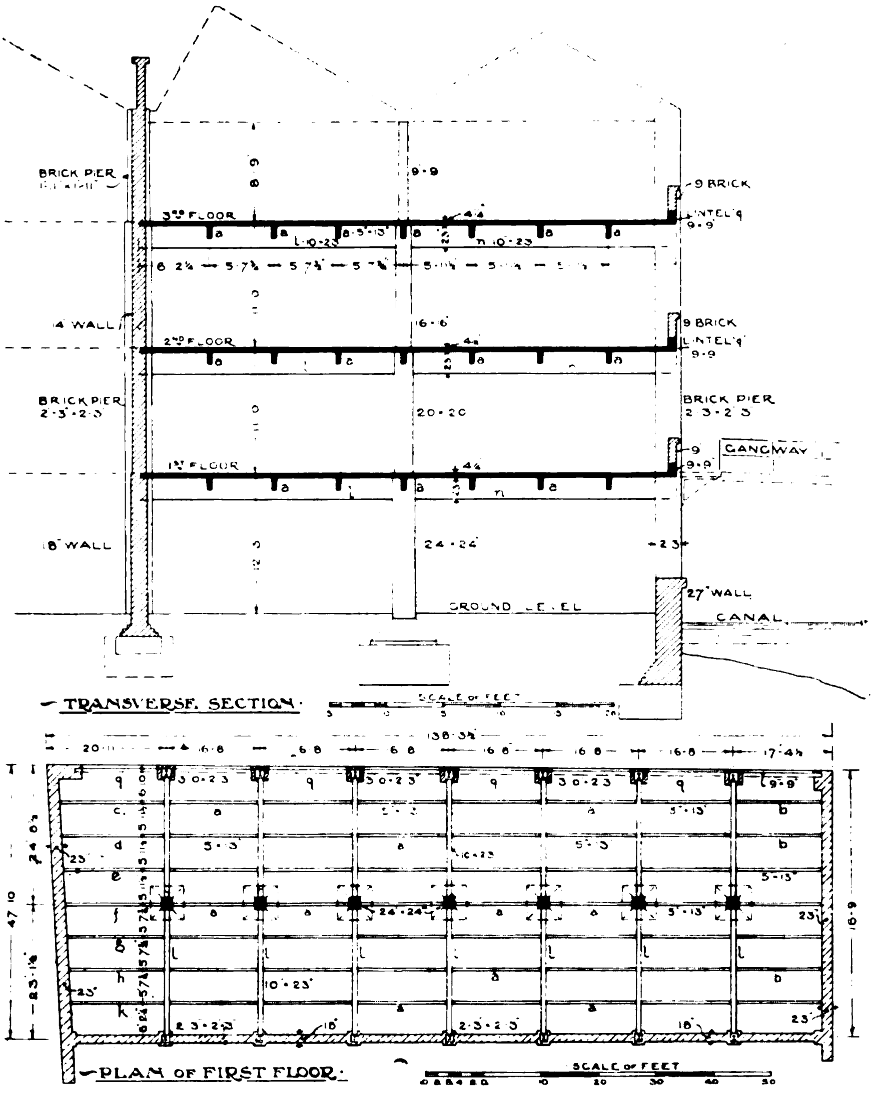
View of one of the dams at low water.



Pulling the piles after the pier has been built.

COFFERDAMS FOR VIADUCT AT LOUGHOR.

The work was carried out by Messrs. Walter Scott & Middleton, Ltd., of Westminster, who are constructing the new Fishguard line for the Great Western Railway, and the piling was supplied by the British Steel Piling Co., of Dock House, Billiter Street, E.C.

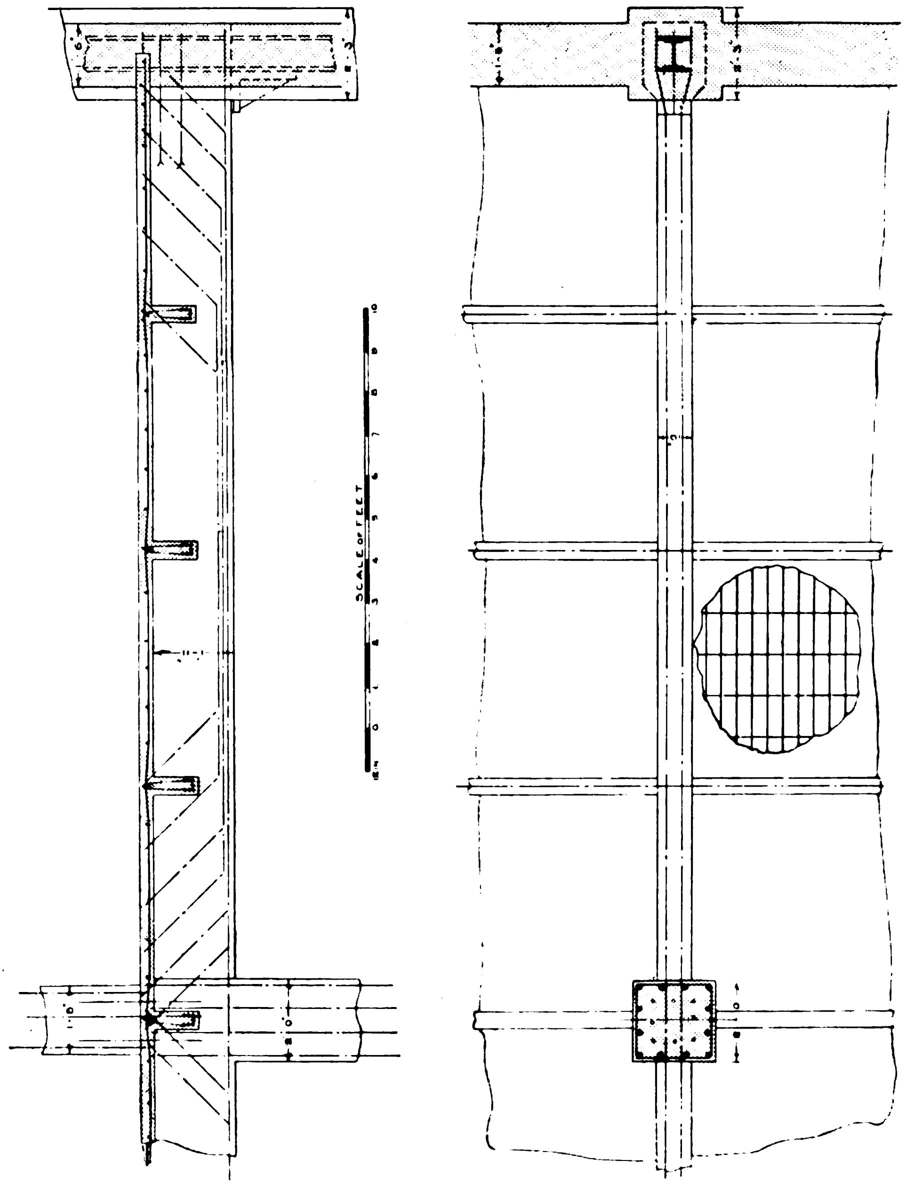


Reinforced Concrete Warehouse for J. Baldwin & Sons, Ltd., Birmingham.

WAREHOUSE FOR MESSRS. BALDWIN & SONS, LTD., AT BIRMINGHAM.

The accompanying illustration shows the front elevation of a large warehouse, recently executed for Messrs. James Baldwin & Sons, Ltd., paper manufacturers, of Birmingham.

This building contains three reinforced concrete fire-resisting floors, supported by pillars.



Plan of first floor, showing rails.

REINFORCED CONCRETE WAREHOUSE FOR J. BALDWIN & SONS, LTD., BIRMINGHAM

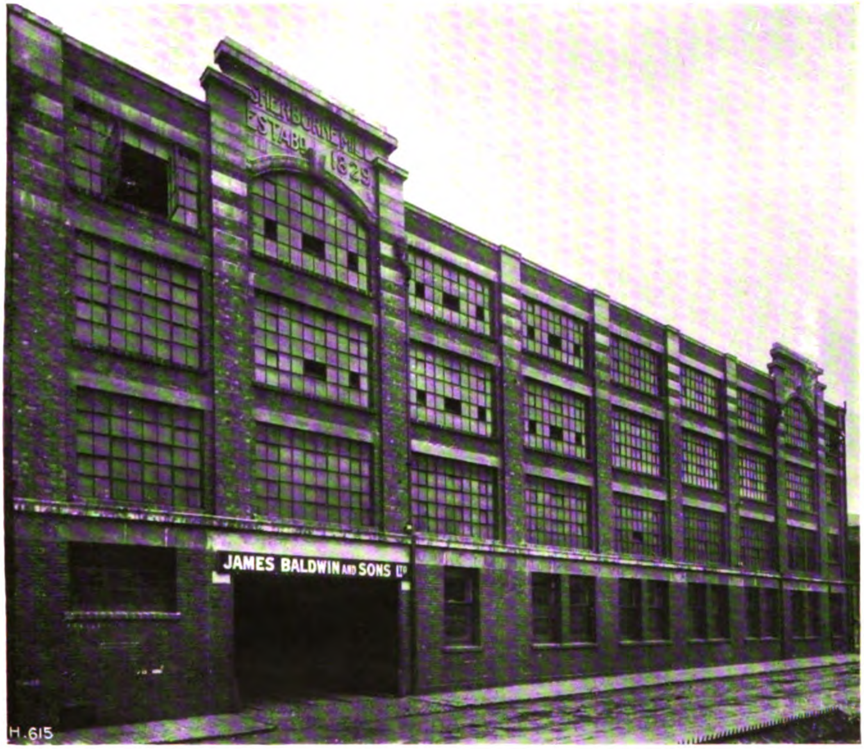
The architects for the work were Messrs. Ewen Harper & Bros., and the contractors were Messrs. Richard Fenwick, Ltd., of Birmingham.

The work has been executed on the Coignet system of reinforced concrete.

The general dimensions of the floors are approximately 134 ft. by 46 ft. They have been calculated for a superload of 2 cwts. per sq. ft. with a factor of safety of 5.

The scantlings of the main beams are 10 in. wide by 23 ft. deep, and the thickness of the slab is 4¼ in. The span of the main beams is 21 ft., and these are supported by a central row of columns calculated to carry approximately 190 tons each. The scantlings of these are 24 in. by 24 in. on the ground floor, 20 in. by 20 in. on the first floor, 16 in. by 16 in. on the second floor, and 9 in. by 9 in. under the roof.

The walls of the building are in brickwork of the usual required thickness, and the roof is built in steel.



View of finished buildings.
REINFORCED CONCRETE WAREHOUSE FOR MESSRS. J. BALDWIN & SONS, BIRMINGHAM.

BRIDGE AT MAULD, STRUY-BY-BEAULY.

THE illustrations on page 926 show a bridge recently erected in reinforced concrete over the River Glass, at Struy-by-Beauly, Inverness-shire.

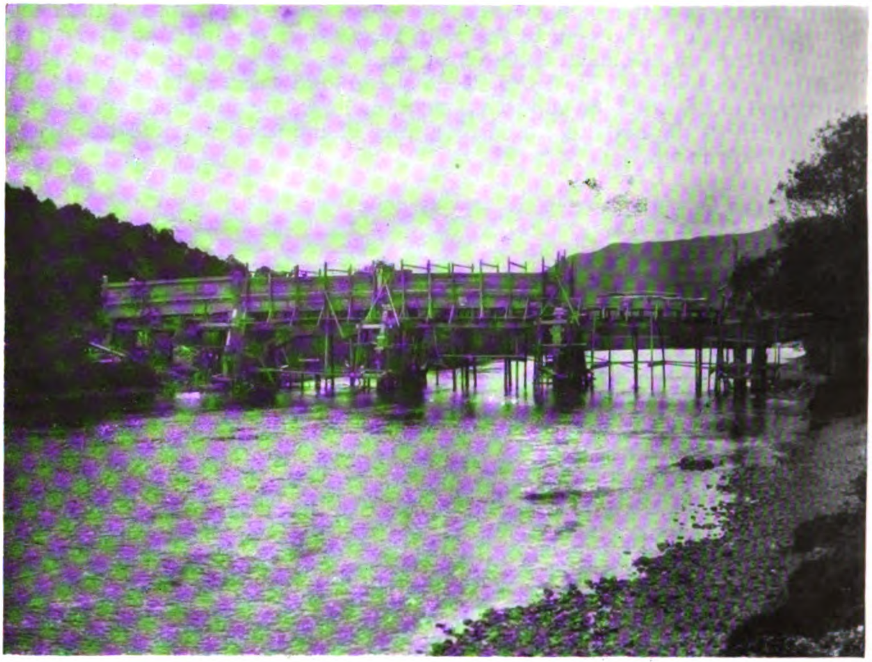
The work was carried out by Messrs. McLaughlin & Harvey, contractors, of Belfast and London, from the designs and under the supervision of Messrs. Scott & Fraser, Consulting Architects, London.

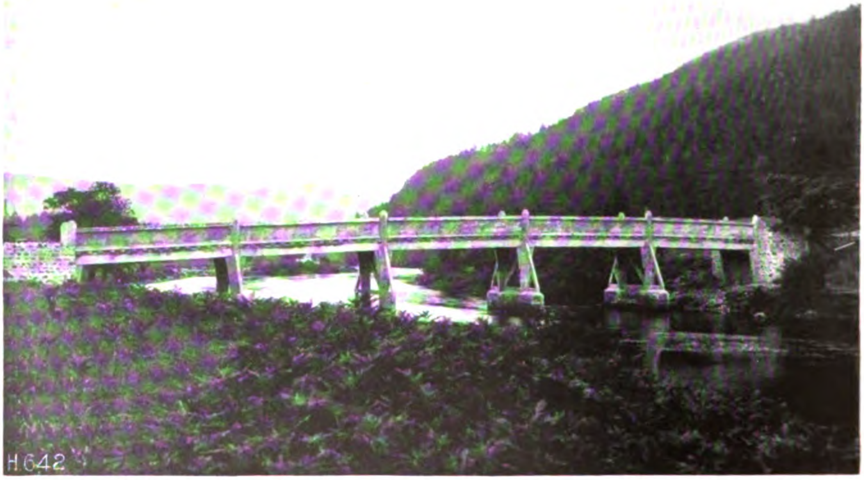
This structure, which is the farthest north reinforced concrete bridge, is about 180 ft. long, with a width of 12 ft., the spans being about 36 ft.

The river at this point is liable to floods and a very rapid flow. The bridge has been designed so as to protect the piles and piers against the shock of floating timber and blocks of ice during the winter months.

The cement was supplied by the Associated Portland Cement Manufacturers, Ltd., and the steel and cement were tested by Messrs. D. Kirkaldy & Sons.

View of bridge in course of construction.





View of finished bridge.

REINFORCED CONCRETE BRIDGE AT STRUY-BY-BEAULY.

LOAD TESTS UPON REINFORCED CONCRETE FLOORS, G.P.O. EXTENSIONS, BELFAST.

SOME interesting load tests upon floors constructed upon their system have recently been made by the Irish Armoured Tubular Flooring Co., Ltd., of which views are given, with short extract of results obtained. These floors of 17 ft. 7 in. clear span were designed for super load of 168 lb. per sq. ft., loading materials being 2 cwt. bags of gravel.

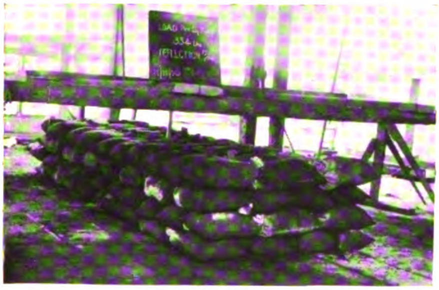


FIG. 1. 3 CWT. PER SQ. FT.

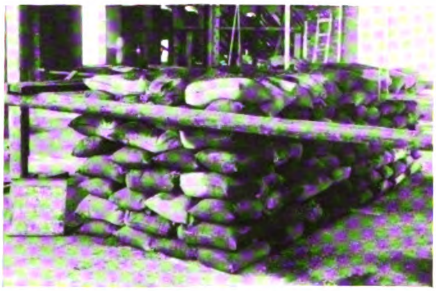


FIG. 2. 6 CWT. PER SQ. FT.

ALL LOADS IN LBS. PER SQ. FT.

Test No.	Total applied Load.	Per sq. ft.	Floor Load.	Total Load.	Deflection in parts of Clear Span.
1	17,920 (8 tons)	171	77	248	1/1636th
2	35,840 (16 tons)	341	77	418	1/620th
3	77,280 (34½ tons)	663	77	740	1/300th

Test to destruction upon a four-joist sample of 25-ft. span at Handsworth Schools gave equally satisfactory results, the designed super load being 112 lb. and the load inducing fracture being 580 lb., with deflection $\frac{1}{252}$nd part of span under total applied load of 27 tons 7 cwt.

These, amongst other test results of an equally satisfactory nature, prove that the basis of design in these floors complies with the full requirements of the best modern practice in reinforced concrete construction.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

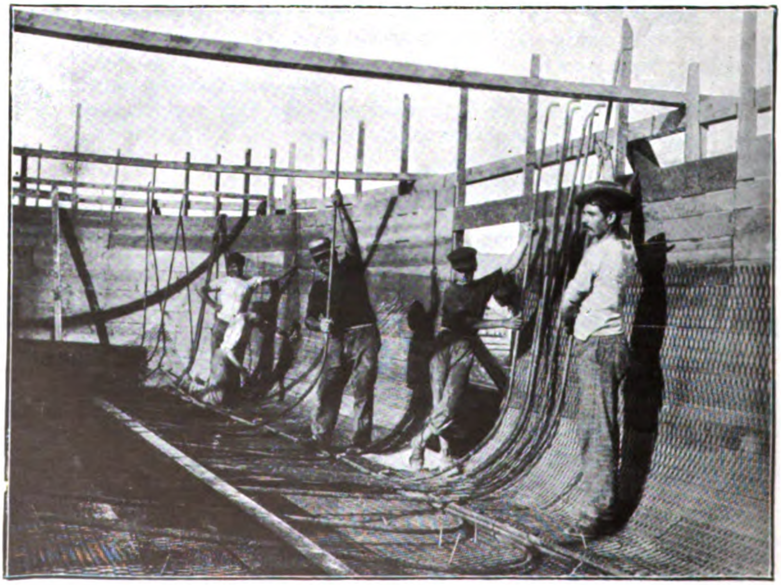
NOVEL APPLICATIONS OF CONCRETE REINFORCED WITH EXPANDED METAL.

DURING the last few years we have, under the heading of "New Uses for Concrete," presented a large number of examples and ideas of the economic and practical application of concrete and reinforced concrete to every-day purposes, and more particularly with the uses to which it can be applied on country estates, on farms, and generally in rural property.

Where a reinforcement of the concrete by metal is advisable or necessary the difficulty for the layman is generally that of obtaining suitable material, and although for odd jobs any old rods, old iron fencing, or the like can very often be made to fulfil the requirements, this is obviously not the case where systematic work is under consideration, and where either a supply of special bars or some other form of reinforcement has to be obtained.

It is thus with considerable interest that we note that the Expanded Metal Co. has been laying itself out to provide Expanded Metal for every-day use for reinforced concrete, and in a catalogue recently issued (Pamphlet No. 2, 1910) that company not only describes the various uses to which their reinforcement can be put, but gives interesting particulars as to the various types of the reinforcement they provide and examples of their work done with this material.

The catalogue is so instructive that we are reproducing some of the illustrations presented therein relating to the construction of tanks, fence-posts, and barges.

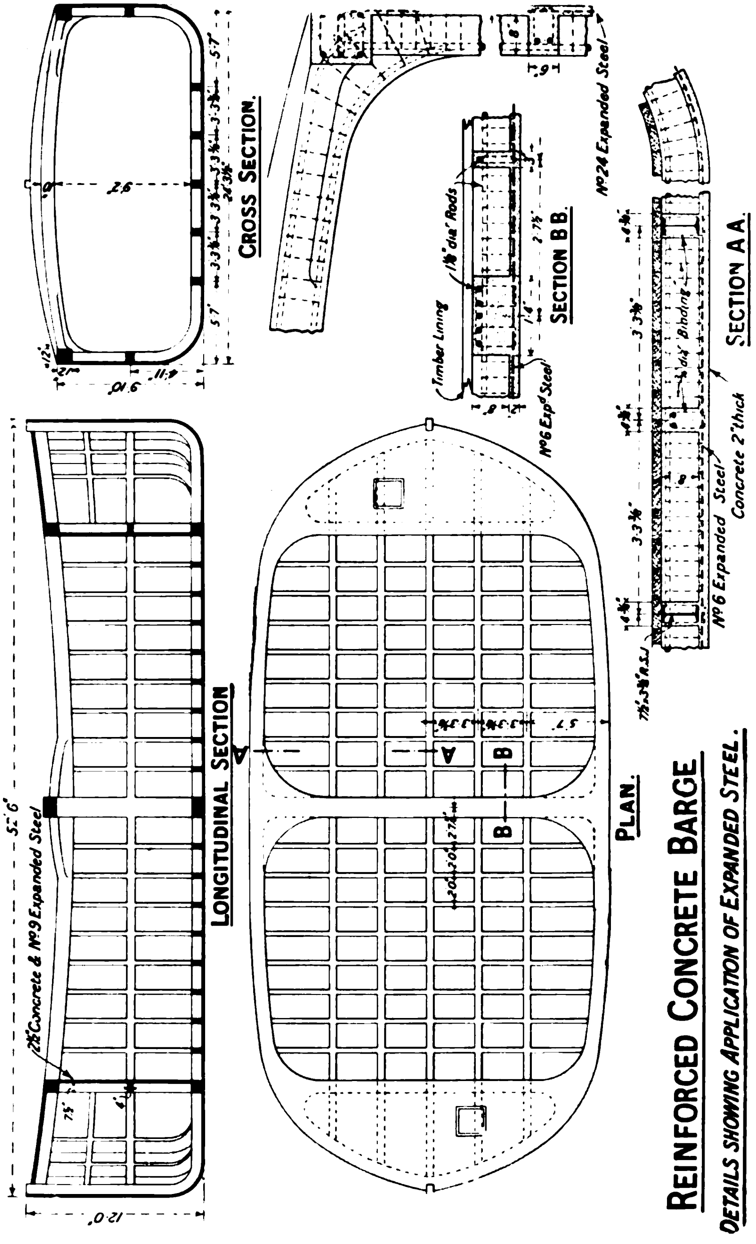


REINFORCED CONCRETE BARGE IN COURSE OF CONSTRUCTION.

The illustrations on these pages explain themselves, but the following are some particulars that may be of interest.

A CONCRETE BARGE.

The barge illustrated was constructed by the licensees of the Expanded Metal Co. in Italy. It was designed for towing purposes, and was constructed by means of temporary timbering, which would not, however, be necessary for smaller barges. The concrete used was composed of 3 parts ¾-in. aggregate, 1½ parts of sand, and



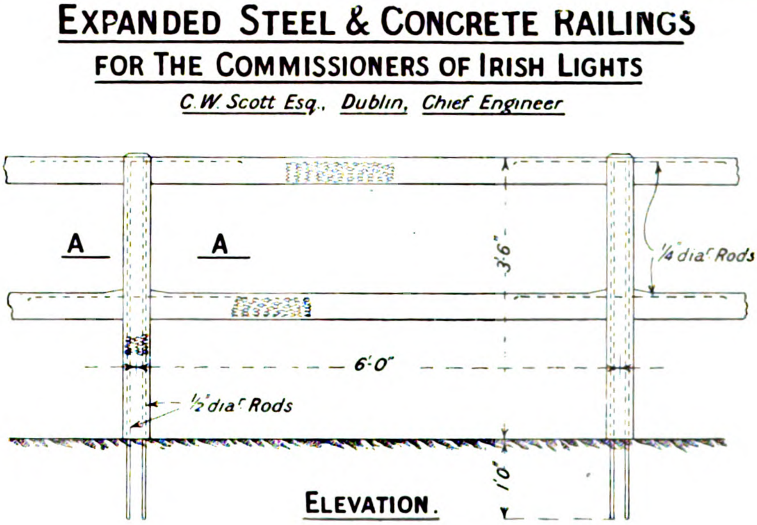
REINFORCED CONCRETE BARGE

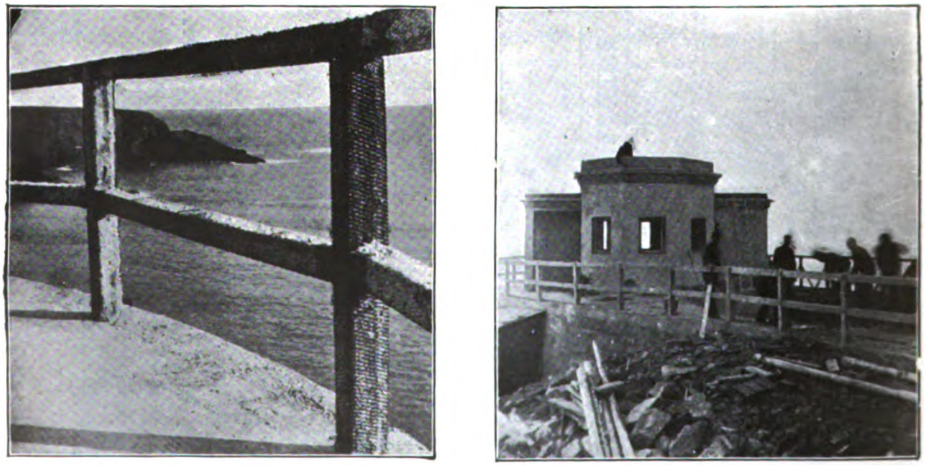
DETAILS SHOWING APPLICATION OF EXPANDED STEEL.

1 part of Portland cement. It was built in 1906, since when it has been in constant use for coal traffic, carrying about 150 tons, and is still giving satisfactory results. Details of the construction are given on another page

RAILINGS.

On this page we show some reinforced concrete railings built for the Chief Engineer of the Commissioners of Irish Lights. These railings were constructed *in situ* of a basketwork of round rods and ¼-in. Diamond Mesh Expanded Steel, into which concrete was placed, the whole being covered with cement mortar finished off to a hard, polished surface.


EXPANDED STEEL & CONCRETE RAILINGS
FOR THE COMMISSIONERS OF IRISH LIGHTS
C. W. Scott Esq., Dublin, Chief Engineer
A
A
3'6"
¼" diar Rods
6'0"
½" diar Rods
1'0"
ELEVATION.



REINFORCED CONCRETE RAILINGS FOR COMMISSIONERS OF IRISH LIGHTS.

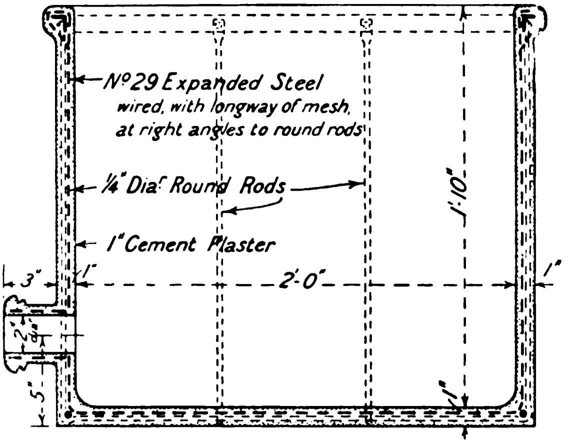
CONCRETE TANKS.

A great number of tanks, in which concrete or cement plaster and Expanded Steel were used, are illustrated in the catalogue, the one we reproduce on page 931 being an acid tank for Messrs. J. Dickinson & Co., Ltd.

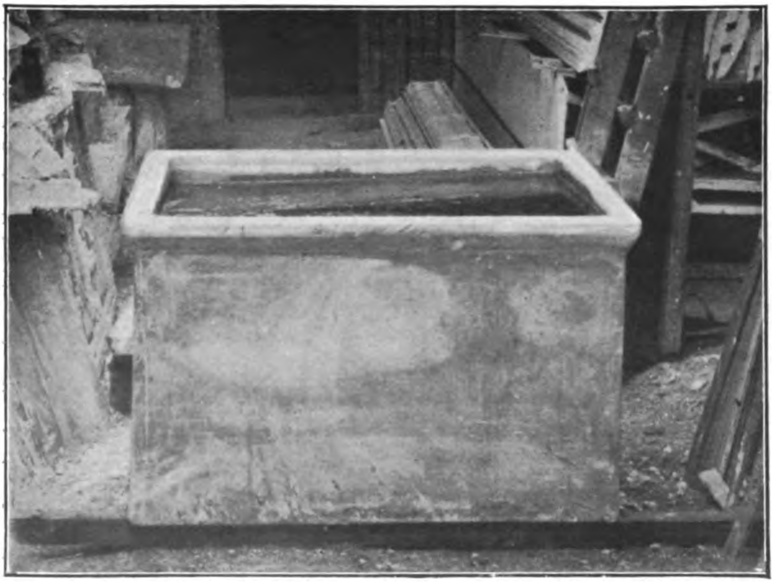
In every case it should, however, be borne in mind that reinforcement in the form of Expanded Steel is especially useful for minor purposes of this description, as are, speaking generally, the majority of the mesh or prepared reinforcements on the market.

ACID TANKS FOR MESS^{RS} J. DICKINSON & CO. L^{TD}

EXPANDED STEEL & CEMENT PLASTER.


Nº 29 Expanded Steel wired, with longway of mesh, at right angles to round rods
¼" Diaʳ Round Rods
1" Cement Plaster
3"
1"
2'-0"
1"
1'-10"
1"
2"
5"

CROSS SECTION.



ACID TANKS MADE WITH CEMENT PLASTER AND EXPANDED STEEL.

We think the Expanded Metal Co. were well advised to publish these particulars in their catalogue, and other firms having the minor uses of concrete in mind would do well to popularise the subject by similar publications.

CORRESPONDENCE.

Under this heading we invite correspondence.

BLACKPOOL : *November 17th*, 1910.

INTERIM REPORT ON REINFORCED CONCRETE.

SIR,—I note in above report that Mr. A. E. Wilson, C.E., makes some reference in his evidence to the use of trass as an admixture for cement concrete, and gives his opinion that the subject is worthy of careful consideration. The advantages Mr. Wilson seeks to obtain are greater impermeability and a prevention of the centre of the mass remaining green.

Mr. Wilson states that the latter object has been secured by the use of a slow-setting cement, but I venture to submit that this method involves uncertainties which do not occur when trass is used. The time required in the setting of any cement will largely depend upon temperature and other external conditions, as also to some considerable extent upon the peculiar nature of the aggregates used, all of which cannot be the same in actual work as in the laboratory in which the initial tests are made, to ascertain whether a cement is quick or slow setting. In illustration of this an experience was related at one of the early meetings of the Concrete Institute, which went to show that the same cement which was quick setting when used at Devonport, was slow setting under similar conditions in the North of Scotland, owing apparently to a variation in temperature. Whilst the probabilities of a too-rapid surface-hardening may be decreased by the use of a slow-setting cement, the danger of the interior still remaining green cannot be entirely obviated.

Mr. Wilson gives the experience of Mr. Werner, at Aberdeen, that trass made the concrete more water and air-tight.

This it would certainly do ; but I respectfully suggest that it would also do something of more importance than make the cement a little slower in the initial process of setting, as by entering into combination with the lime particles in the cement it would produce a permanent hardening in the interior of the mass (and removed from contact with the air) with equal rapidity to that process on the exterior. If the concrete mixture is sufficiently open to allow the combination of air with the binding materials in the centre of the mass, notwithstanding a slower setting cement being used, the resultant impermeability which Mr. Wilson claims as desirable in all reinforced concrete construction will not exist. I was privileged some little time ago to examine the effect of trass in the interior of one of the piers of a railway bridge over the Rhine, at Coln, which was being taken down to be replaced by a larger structure. This bridge had been built about sixty years, and in the centre, some 8 ft. from the outer surfaces, of one of the piers, the mortar was as hard as at the surface, and as firmly attached to the surrounding stone as if a part of its structure. In the construction of the new bridge the standard specification issued by the Administration of State Railways has been used, and all mortars and concretes contain equal proportions of trass and cement in addition to the ordinary aggregates of sand and stone. Another peculiarity of trass, which is an advantage to reinforced and other concrete, is that its admixture imparts a flexibility to the concrete it would not otherwise possess.

In a recent paper I contributed to a meeting of the Association of Municipal and County Engineers on the subject of concrete, I ventured to suggest that a careful selection of aggregates, proportioning of volumes, and intimate mixture of particles, were necessary to secure efficiency in all reinforced and other concrete constructional work, and claim that a consideration of the methods I then advocated would tend to secure most of the essentials deemed to be desirable by the several witnesses who gave contributions in the report to which I have taken the liberty to refer.

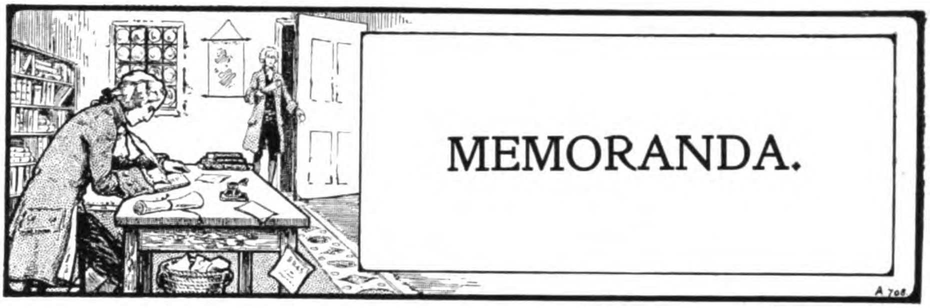
I further claim that without the use of trass or some admixture containing similar properties, equality of permanent hardening in the mass and impermeability in concrete cannot be assured.

Yours faithfully,

WILLIAM CHALLONER.

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

We do not hold ourselves responsible for opinions expressed by correspondents.—ED.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Cement Concrete Vats and Tanks.—Mr. Albert Moyer, Assoc.Am.Soc.C.E., sends us the following data *re* the treatment of inside surfaces of concrete vats and tanks :

Impervious, odourless, tasteless, and sanitary vats and tanks for butter-milk, wine, oil, pickles, sauerkraut, etc., can be constructed of reinforced concrete, the reinforcing to be designed by a competent engineer, provided the interior surfaces are treated as follows :

After the forms are removed, grind off with a carborundum stone any projections due to the concrete seeping through the joints between the boards. Keep the surface damp for two weeks from the placing of the concrete. Wash the surface thoroughly and allow to dry. Mix up a solution of 1 part water-glass (sodium silicate) 40° Baume, with 4 to 6 parts water, total 5 to 7 parts, according to the density of the concrete surface treated. The denser the surface the weaker should be the solution.

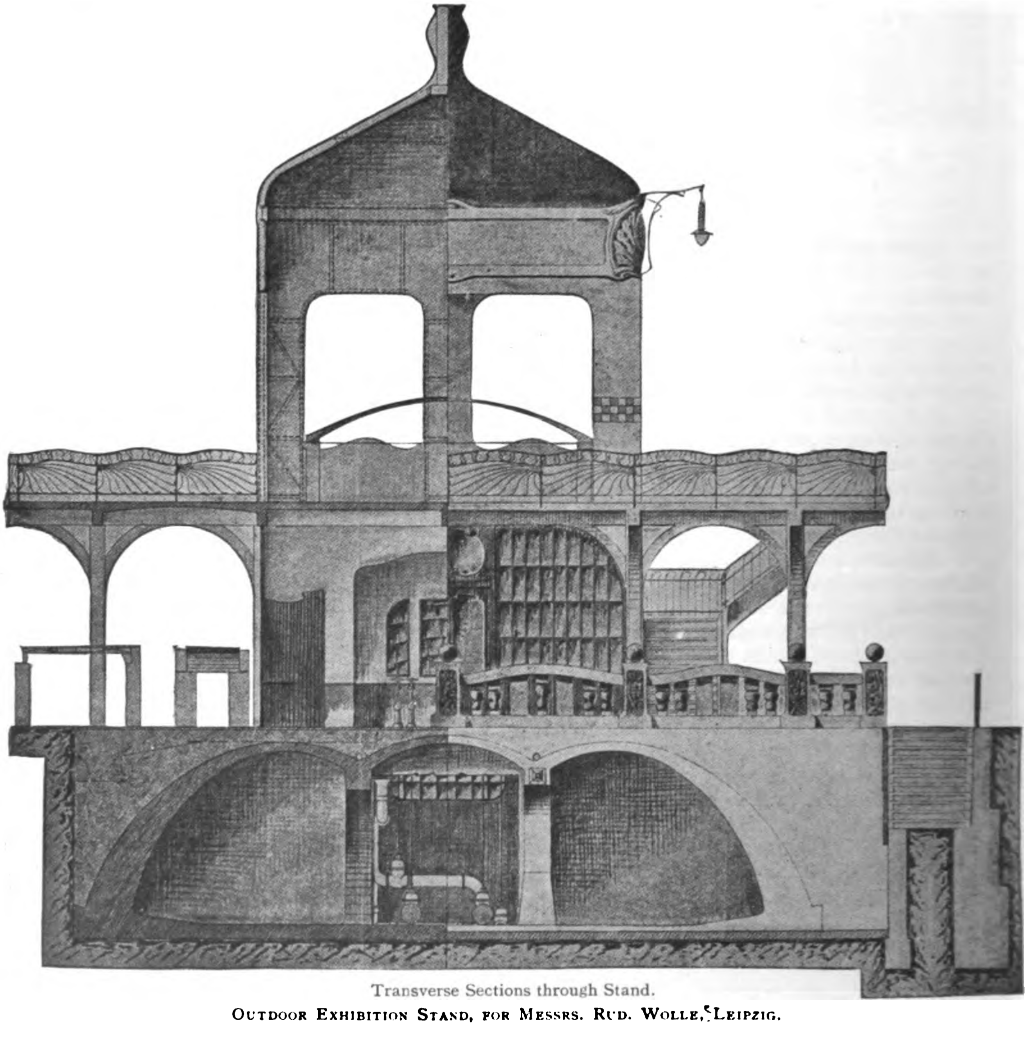
Apply the water-glass solution with a brush. After 4 hours, and within 24 hours, wash off the surface with clear water. Again allow the surface to dry. When dry, apply another coat of the water-glass solution. After 4 hours, and within 24 hours, again wash off the surface with clear water and allow to dry. Repeat this process for 3 or 4 coats, which should be sufficient to close up all the pores. The water-glass (sodium silicate) which has penetrated the pores has come in contact with the alkalies in the cement and concrete, and formed into an insoluble hard material, causing the surface to become very hard to a depth of ⅛ to ½ in. according to the density of the concrete. The excess sodium silicate which has remained on the surface not having come in contact with the alkalies is soluble, therefore easily washed off with water. The reason for washing off the surface between each coat, and allowing the surface to dry, is to obtain a more thorough penetration of the sodium silicate.

It is obvious that concrete surfaces so treated, if hard, impervious, and insoluble, have been made impervious, tasteless, odourless, and sanitary.

Whitewash for Concrete Surfaces.—Common whitewash has been used on concrete surfaces in order to give a white, rather than a grey, cement tone. It is, however, frequently lacking in durability, and the *Cement Age* suggests that where greater adhesion is desired better results may be obtained with the whitewash used by the Government on its lighthouses. The following formulæ for whitewash and cement have been furnished to the above journal by the Department of Commerce and Labour :

> ***Whitewash.***—Slake half a bushel of unslaked lime with boiling water, keeping it covered during the process. Strain it and add a peck of salt, dissolved in warm water ; three pounds of ground rice put in boiling water and boiled to a thin paste ; half a pound of powdered Spanish whiting, and a pound of clear glue, dissolved in warm water ; mix these well together and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace, and when used put it on as hot as possible with painters' or whitewash brushes.
>
> ***Cement Wash for the Outside of Lighthouse Towers.***—Take of fresh cement 3 parts, clear sand 1 part, and mix them thoroughly with fresh water. This will give a grey or granite colour, dark or light, according to the colour of the cement. If a brick colour is desired, add enough Venetian red to the mixture to produce that colour. The cement, sand and colouring matter

must be mixed together. If white is desired, the walls, when new, should receive two coats of cement wash and then whitewash. After the work has received the first coat, a single coat every three or four years will be sufficient. It is best to thoroughly dampen the wall with clean, fresh water, and follow immediately after with the cement wash. This course will prevent the bricks from absorbing the water from the wash too quickly, and will give time for the cement to set. Care must be taken to keep all the ingredients of the cement wash well stirred during the application of it. The mixture must be made as thick as it will admit of to be conveniently put on with a whitewash brush.



Transverse Sections through Stand.

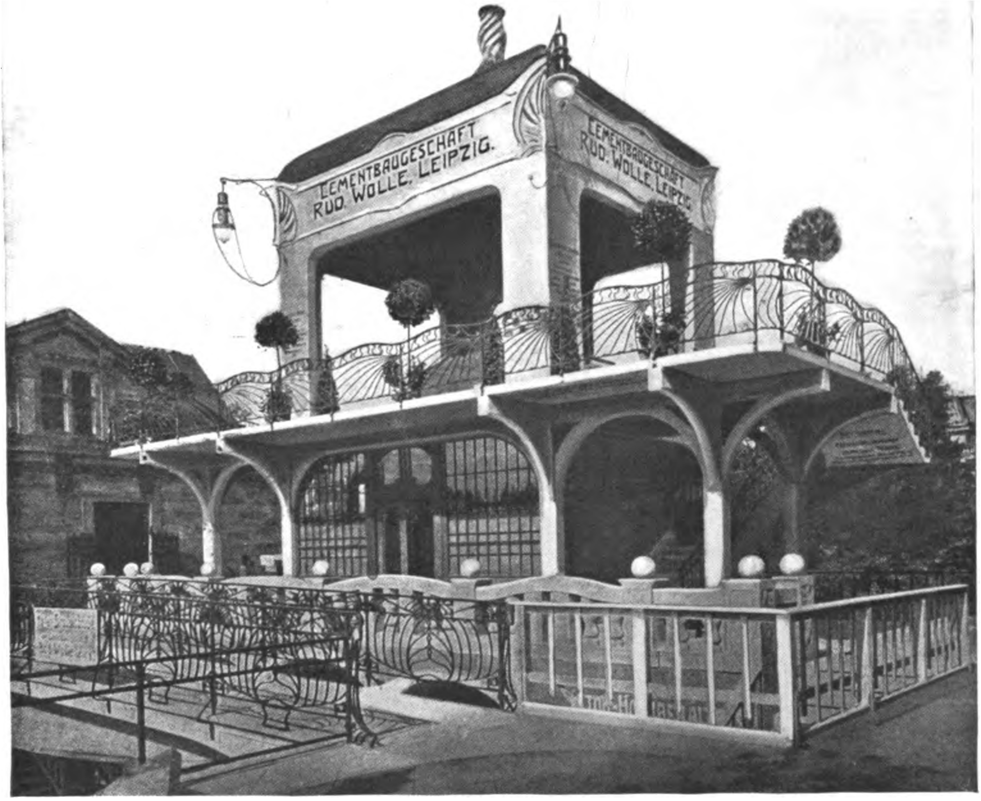
Outdoor Exhibition Stand, for Messrs. Rud. Wolle, Leipzig.

To Prevent Dusting or Easy Abrasion of Concrete Floors.—The following method of preventing dusting of concrete floors has been sent us by Mr. Albert Moyer, Assoc.Am.Soc.C.E. :

Cement floors, improperly laid, which have been allowed to become prematurely dry, are porous and weak, causing easy abrasion under foot traffic, or what is commonly known as dusting. This can be remedied as follows :

Wash the floor thoroughly with clear water, scrubbing with a stiff broom or scrubbing-brush, removing all dirt, allow the surface to dry. Mix 1 part water-glass (sodium silicate) of 40° Baume, with 3 to 4 parts of water, total 4 to 5 parts, depending upon the porosity of the concrete. The denser the concrete, the weaker the solution required.

Apply with a brush one coat evenly over the entire surface. This will penetrate into the pores of the concrete. Allow the concrete surface to dry, after 24 hours apply another coat the same as before. Again allow the surface to dry, and apply another coat. If after 24 hours the third coat is not flush with the surface in any part of the floor, apply another coat. That which remains on the surface can be readily washed off, thus evening up the floor. That which has penetrated into the pores has come in contact with the alkalies and salts in the concrete and formed into an insoluble, very hard mineral glue.


CEMENTBAUGESCHAFT RUD. WOLLE. LEIPZIG.
CEMENTBAUGESCHAFT RUD. WOLLE. LEIPZIG

OUTDOOR EXHIBITION STAND, FOR MESSRS. RUD. WOLLE, LEIPZIG.

Concrete Exhibition Stands.—Having regard to the numerous exhibitions which are constantly taking place, and particularly to the Building Trades Exhibition to be held early next year, we are reproducing two somewhat interesting illustrations of a concrete outdoor exhibit, which was erected in Germany for Messrs. Rud. Wolle & Co., of Leipzig. We think these merit the attention of those concerned in the concrete industry for exhibits of this kind.

Bonding Successive Layers of Concrete.—Joints between successive layers of concrete which are considered very satisfactory by the maker have been obtained by the following treatment. The approximately horizontal surface of the concrete, which is to be bonded to a subsequent layer, is allowed to stand until any water which may have flushed to the top disappears. Then, while the mass is still moist,

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ILLUSTRATIONS SHOW CENTERS IN USE ON COMBINED BRICK AND CONCRETE CULVERT, FOR THE NORTH-EASTERN RAILWAY CO., AT BLYTH, NORTHUMBERLAND.

THE CONTRACTOR FOR THE WORK WAS MR. T. TELFORD GIBB.

THE BRITISH STEEL PILING COMPANY,

DOCK HOUSE, BILLITER ST. LONDON. E.C.

the surface is covered with about ½ in. of a 111 dry mixture of cement and sand, and protected, if necessary, with tarpaulins or boards. The moisture still remaining in the concrete suffices to produce a partial set in the dry mixture immediately adjacent to the surface of the concrete, and above that to affect the mixture in a diminishing degree, the upper part of the mixture being unchanged. When it is convenient to apply the next layer of concrete, the moisture in it completes the set through all of the unhardened dry mixture, interlocking the two courses, as it were. The joint between the two layers of concrete, although visible, is stated to make a much stronger bond than is usually secured.

A number of briquettes have been made of cement mortar cast in two parts, and connected by a joint formed in this manner, and when tested developed a strength of more than 50 per cent. of the normal briquette of the same mixture made in a single piece.

This form of bond between successive layers of concrete was devised, and has been extensively used by Mr. J. A. Jamieson, of Montreal, Canada, in the construction of a reinforced-concrete elevator, a reinforced concrete conduit 10½ ft. in diameter and 8,000 ft. long, working under 33 ft. head, and for other works.

Concrete in Palestine.—In the frontispiece to this issue we give a reproduction of the Kaiserin Augusta Victoria Sanatorium in Jerusalem. The floors throughout the building are hollow tiles and concrete. Where the span is considerable, two I-beams, about 16 in. apart, are used, filled in with reinforced concrete. These double I-beams are placed about 13 ft. apart. Boards close together are then put in place, either hung to the I-beams or supported by posts from below, on which are laid hollow bricks. A space of 1⅗ in. is left between the bricks each way, and iron rods, 0·6 to 0·7 in. in diameter, are laid in between the bricks running the shortest way. The rods lie flat near the bottom of the space, and pieces of stiff paper are used to cover both open ends of all the bricks to prevent their being filled with the concrete, which is poured in until it covers them 1⅗ in., making the total thickness of the floor 8 in. In this way the floor is formed of concrete T-beams, running in both directions, one reinforced, and one not, with a brick to fill up each of the empty squares left.

The concrete is made of cement and sand only.

The bell-tower, 197 ft. high, is finished inside with concrete steps from the second storey up. The steps are about 42 in. long, with about 10 in. built into the wall, and on the under side are slanting, the top one lapping slightly over the one below. The staircase, not otherwise supported, goes around the four inside walls, and at the corners square reinforced landings are made, supported by I-beams embedded in concrete. These steps were only half the cost of stone ones. The method of building, which is new to Palestine, has given great satisfaction.

Reinforced Concrete in Belgium.—The report of the Second Congress of the National Federation of Building and Public Works Contractors of Belgium, held in Brussels in June last, has just been issued, and among the various items we note the following: The Congress desired to have adopted in Belgium, Standard Specifications for reinforced concrete work, and suggested that this was a matter in which the State might help by setting up such standards and requiring all administrations to adopt them.

Construction of Fever Hospitals.—From a paper submitted by A. Saxon Snell, F.R.I.B.A., to the Royal Sanitary Institute Congress at Brighton, we take the following extract: " It has been sought to reduce the cost of hospital buildings by constructing them of light and cheap materials—generally timber framing lined with boarding and galvanised iron; and this method has been advocated also on the ground that all fever hospitals ought to be pulled down and burnt within a limited number of years. They are, however, wasteful of heat, require great expense in repair and upkeep, and they are necessarily crowded with dust and germ-holding corners, angles, and hidden spaces.

" There are, however, modern methods of erection not open to these objections, and it has always appeared to me that excellent buildings at comparatively small cost could be obtained with steel framing filled in with light concrete construction.

The walls might be formed with two thin slabs fixed so as to cover the steel work, and with a small air space between them which would help to keep the building wind and weather-tight and reasonably warm. The floors would be formed with concrete laid between steel joists, and covered with one or other of the many patent compositions in the market, which are both impervious and cheap. The ceilings would be formed in the same manner as the walls. With such a method of construction it is easy to obtain those flat and even surfaces, unbroken by unnecessary and dust-collecting ledges and angles, which are to be avoided at all costs in fever wards. Periodically the concrete filling and surface finishings might be removed and reinstated with new material. The steel framework would require washing only. Such buildings, or, rather, the framework, could be taken down with comparative ease and at small expense for re-erection on a different site if required; and their cost, although greater than ordinary wood-framed constructions, would be far less than for brick and stone buildings."

TRADE NOTICES, ETC.

British Reinforced Concrete Engineering Co., Ltd., of 196 Deansgate, Manchester.—At the annual meeting of this company the report of the directors recommended payment of a dividend of 40 per cent. on the whole of the issued shares, and that a sum equal to 20 per cent. be carried to reserve fund.

The demand for the company's specialities has increased very rapidly during the year, and at the present time they are extremely busy. The report was adopted.

OCT 30 1917

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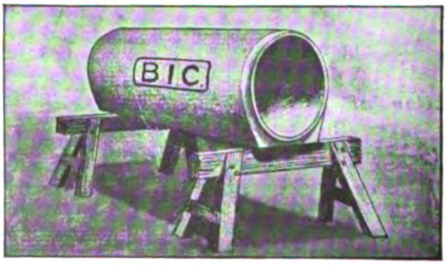

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